SCIENCE ABSTRACTS.

Section A.—PHYSICS.

JUNE 1916.

GENERAL PHYSICS.

636. *Practical Method of Tracing Curves.* **A. H. Shield.** (Inst. Civ. Eng., Proc. 199. pp. 430–440, 1914–1915.)—The method here described, though not mathematically correct, is nevertheless sufficiently accurate for most practical purposes. With ordinary care and skill a parabola, hyperbola, or logarithmic curve can be drawn with the same approach to accuracy as a circle is drawn with the usual drawing instruments. Further, it can be drawn much more quickly and more neatly than by determining points in the curve by computation, or by intersections, and subsequently tracing the curve through these points. The practical use of the method is limited to those curves for which the quantity $d = y/(dy/dx)$ takes a simple or easily computed form. To make use of this quantity d for drawing a curve, a number of lines are taken at short distances apart and a point P_1 on the curve having been found by computation or otherwise, tangents are drawn in the direction of points Q_1, Q_2, Q_3, etc., on the x-axis, located at distances d_1, d_2, d_3, etc., respectively from the vertical lines passing through the points P_1, P_2, P_3, etc., through which the tangents are drawn. Each tangent is drawn from a point midway between two vertical lines to a point midway between the next pair. The result is a series of tangents which, if the vertical lines are taken sufficiently close together, is indistinguishable from a smooth curve. The error involved in the assumption that the enveloping tangents intersect midway between the ordinates may be kept within assigned limits by taking the ordinates sufficiently close together. Three general types of curve may be treated easily by this method: (1) $y = cx^n$, for which $d = x/n$; (2) $y = ae^{bx}$, for which $d = 1/b$; (3) $y = ca^x$, for which $d = 1/\log_e a$. A number of illustrative diagrams are given. A. W.

637. *The Current "Definition" of Energy.* **M. M. Garver.** (Science, 43. pp. 567–571, April 21, 1916.)—This letter to the editor refers to the view taken by Millikan of the existing confusion in the use of the word "energy" in many text-books. Garver considers that if we *accept* the conservation of energy as an established *principle*, then we must accept the legitimate deduc-

tions from it or abandon it as a principle. Neither the view that energy is a capacity of doing work, nor the view that makes work a "form of energy" is consistent with considering work a *transference* of energy; also while the last view is consistent with the principle of conservation the other two are not.

L. H. W.

638. *Viscosity of Liquids.* III. **G. Zemplén and B. Pogány.** (Ann. d. Physik, 49. 1. pp. 39–70, Feb. 4, 1916.)—By means of Zemplén's apparatus for investigating the viscosity of gases [see Abs. 1158 (1912)], the viscosity of water has been measured by the deflection method, the period of rotation of the outer sphere varying from 0·17 sec. to 9800 secs. At 18° the coefficient of viscosity is found to be $\eta_{18} = 0{\cdot}010562$. Graphical treatment of the experimental data shows that the regularity relating to the moment of the viscous forces, deduced by Zemplén and verified in the case of gases, also holds with water. Within the region of velocity investigated no turbulent motion occurs, whereas such should be the case if Reynolds' criterion were applicable to the liquid between the two spherical surfaces. The results show further that the criterion of Rayleigh and Lamb indicating the limits of applicability of the formula for slow movements, agrees so far as order of magnitude is concerned in the case of water, but gives a value 50 to 100 times too small in the case of gases. From the results obtained with spheres of different radii the conclusion is drawn that with quite slow revolutions the coefficient of slipping is $\lambda < 0{\cdot}008$ cm. and may therefore be neglected in practice. T. H. P.

639. *Sources of Error in Viscosity Measurements.* **E. C. Bingham, H. I. Schlesinger, and A. B. Coleman.** (Am. Chem. Soc., J. 38. pp. 27–41, Jan., 1916.)—The average pressure to be used in the calculation of a viscosity measurement is not strictly one-half the sum of the initial and final pressures as ordinarily assumed, and the use of this value may lead to considerable error. A method of calculating the correct value has been developed and tested.

In the flow of a liquid through a capillary tube it is immaterial whether the capillary is in a horizontal or in a vertical position. When a liquid flows from a capillary with a trumpet-shaped opening there is a definite loss of kinetic energy, but it is not proved whether the correction is the same as in the case of a capillary with uniform bore. To secure the best results, the capillaries should have ends which are as nearly square as possible, so that the kinetic energy correction may be calculable and the bulbs should be made as short as possible, *e.g.* by making each bulb approximate the shape of two cones placed base to base. The value in relative as well as in absolute determinations of viscosity of using an instrument in which the time of flow may be varied by varying the pressure is further emphasised by the observations now recorded. T. M. L.

640. *Gravitation and Electrical Action.* **F. E. Nipher.** (Acad. Sci. St. Louis, Trans. Science, 43. pp. 472–478, March 31, 1916. Extract.)—The author has previously suggested that there is an intimate relation between gravitation and electrical action at a distance, or what has been called the statical effects. He holds that the attraction between two masses of matter depends not only upon the amount of matter in the two masses and their distance from each other, but also upon their electrical potential.

The gravitation constant has been determined by finding the attraction between two spheres of metal. In those determinations the electric potential of the masses has been ignored. It has been assumed that there are no electrical charges on the two masses, if their potential is that of the earth.

Assume that two spheres, having radii R_1 and R_2 composed of metal having a density ρ, and distant from each other r, have charges Q_1 and Q_2, the spheres having a common potential V. The attractions for each other will be—

$$A = K\frac{m_1m_2}{r^2} - \frac{Q_1Q_2}{r^2} = K\frac{16\pi^2R_1^3R_2^3\rho^2}{9r^2} - \frac{R_1R_2V^2}{r^2}.$$

Here K is the value of Newton's constant of gravitation, as it would be determined by the method of Cavendish or Boys, if V were zero absolute.

If V is not zero, and the second term is omitted, the last equation might be written—

$$A = K\left(1 - \frac{x}{100}\right)\frac{16\pi^2R_1^3R^3\rho^2}{9r^2}.$$

In this equation $K(1 - x/100)$ is the gravitation constant that would be determined under such conditions. Both K and x would remain unknown quantities. Equating these two values of A, $V = \frac{4}{3}\pi R_1R_2\rho\sqrt{(Kx)}/10$. If V is measured in volts, this becomes $V = 40\pi R_1R_2\rho\sqrt{(Kx)}$. If $R_1 = 10$, $R_2 = 1$, $\rho = 11{\cdot}35$, and $K = 6{\cdot}6576 \times 10^{-8}$, then $V = 8{\cdot}68\sqrt{x}$. This result shows that if these two spheres have a common potential which differs from absolute zero by 8·68 volts, the value of K as determined by the Cavendish method will be in error by 1 % of the above value which is that of Boys. If V were ± 8·28 volts, an error of 5 % would result. If V were 86·8 volts the two spheres would cease to attract each other. The absolute zero in V would be the common potential of the two bodies, when their attraction for each other is a maximum.

The smaller the masses used in such determinations the greater will be the possibility of error in the result, when the potential term is ignored. Since we are so much in the dark concerning the average potential of the earth, the author concludes that it is very probable that we do not know the real value of the gravitation constant. E. H. B.

641. *Formation of the Molecule as a Question of the Structure of the Atom.* **W. Kossel.** (Ann. d. Physik, 49. 3. pp. 229–362, March 7, 1916.)—Part I of this paper contains a consideration of those assumptions concerning the constituent parts of the structure of the atom which must be regarded as unconditional. These include especially van den Broek's enumeration of the electrons in the atom which is founded on the facts of Röntgen-ray emission. If, now, the manifestation of valency in polar compounds is regarded solely as an electro-valency—as a substitute for the electron numbers—the distribution of valency in the periodic system leads to a very simple law, according to which the very definite characters of the valency of elements surrounding one of the rare gases are to be regarded as a consequence of the striving to reach the electron-number of the neighbouring stable atom by addition or loss of electrons. As a result of this there emerges the question: To what extent is the charge alone able to furnish the forces acting in a polar molecule?

Part II proceeds to treat of the formation of the molecule. An attempt is made to ascertain if the simplest possible representation of polar compounds—only a charge corresponding with their valency being ascribed to the atoms and no special assumption made concerning the shape of the atom which is idealised as a smooth sphere with the charge at the centre—is able to reproduce the behaviour of such molecules. The case of the ammonium compounds is first considered and then the relation of the above conception to other theories of complex compounds, particularly that of Abegg. The general case of complex compounds is then represented and the most important classes are discussed, with examples; among these the double oxides containing hydrogen furnish a striking example, owing to the characteristic transition from a basic to an acid function. Consideration of the consequences of the above simple representation when applied to the taking up of water or ammonia leads to a peculiar conclusion which distinguishes the proposed, ordinary field of force from any hypothesis assuming a single force. In Part III these considerations are discussed in connection with the questions of Part I. T. H. P.

642. *Optical Test for Angles of Contact.* **A. Anderson** and **J. E. Bowen.** (Phil. Mag. 31. pp. 285–289, April, 1916.)—By means of an optical device for examining the long, cylindrical drop attached to a rectangular piece of very thin glass which has been dipped in a liquid and then held in a vertical plane with two of its edges horizontal, the author finds that the angle of contact of glass with water, glycerine, olive oil, or turpentine is zero. The device also serves for the rough measurement of surface tension. [See Abs. 288 (1916).] T. H. P.

643. *The Statistic-mechanical Basis of the Theory of Quanta.* **T. Wereide.** (Phys. Zeits. 17. pp. 104–106, April 1, 1916. Ann. d. Physik, 49. 8. pp. 965–975, May 23, 1916.)—The difference between the older theory of statistics and that of quanta can be explained as follows:—If the energy of a physical system be defined by the values of the Hamiltonian co-ordinates $p_1 \dots p_n\, q_1 \dots q_n$, these are grouped according to the statistical method in a $2n$-dimensional system. This $2n$-dimensional space defined by its $2n$ co-ordinates is subdivided into equal space elements of dimensions $d\tau = dp_1 \dots dp_n dq_1 \dots dq_n$; in classical statistics the element τd solely plays the part of an integration element, and the formulæ evolved possess their maximum exactitude when $d\tau$ becomes infinitely small. In some cases these formulæ agree completely with experiment, as in the case of the specific heats of gases, but in other cases, *e.g.* dark radiation, there is manifest contradiction. On the quanta theory this difficulty has been very simply overcome by not making $d\tau$ infinitely small, but assigning it such dimensions that the formulæ agree with experience. A physical basis for this apparent arbitrary character of the element $d\tau$ has been sought for in vain. The present paper attempts to show that the contradiction referred to does not exist, and that a finite value can be given to $d\tau$ from a consideration of the classical laws of dynamics, if only the existence of a null-point energy be assumed. The quanta theory is therefore shown to be not in contradiction to statistical mechanics but a consequence of it. [See also Abs. 585 (1916).] H. H. Ho.

644. *Two-dimensional Fields of Flow, with Logarithmic Singularities and Free Boundaries.* **J. G. Leathem.** (Phil. Mag. 31. pp. 190–197, March, 1916.)—In a recent paper [see Abs. 1492 (1915)] the author defined conformal curve-factors, discussed some of their properties, and employed them in the solution of problems of the two-dimensional liquid flow. In all the configurations there discussed the fixed boundary was an open polygon, rectilineal or partly curvilinear, whose continuity was not broken at any point, and the field

was free from singularities. The author here shows how the same calculus may be applied to regions whose fixed boundary is broken and to fields which contain logarithmic singularities, as, for example, to cases of liquid flow between two boundary stream-lines and cases of flow due to sources or vortices.

The method is applied (1) to the motion of a ship in a canal and to the effective inertia of this ship; (2) to electrical flow in a flat conducting strip with a symmetrical hole; (3) to liquid flow with free stream-lines with or without sources and vortices; and (4) to free stream-lines where part of the boundary is curved. E. H. B.

645. *Halo of May 20, 1915, Analysed.* **C. S. Hastings.** (Monthly Weather Rev. 43. pp. 498–499, Oct., 1915.)—Two photographs were taken at Chester, Pa., of this halo at 11.15 and 11.45 a.m. respectively. These are reproduced, and from measurements made from the photographs particulars of the angular size of the halo are determined. It is considered that this halo was not the well-known 22° halo, but the "Oval of Venturi" formed by the upper and lower tangent arcs of the 22° halo uniting when the altitude of the sun is sufficiently great [see Abs. 1619 (1915)]. At the time the first of the two photographs was taken the zenith distance of the sun was 26·1°. At this time the parhelic circle was very brilliant, but at the time of the second photograph, when the sun's zenith distance was about 21·5°, the circle was only just visible. The parhelic circle has not before been recorded with the sun at so great an altitude as this. This rapid diminution in brilliancy with increase in solar altitude is in accordance with the author's theory which attributes the phenomenon to internal total reflection from the smallest surfaces of oriented crystals, and is opposed to the generally accepted theory which explains it by ordinary reflection from the larger surfaces of oriented crystals. As regards the "Oval of Venturi" itself, which forms the most prominent feature of both photographs, the measurements made of the horizontal semi-diameter (24·6° at 11.15 and 28·9° at 11.45 a.m.) are in good agreement with Venturi's theory. J. S. Di.

646. *Working up Wind Observations.* **J. W. Sandström.** (Monthly Weather Rev. 43. pp. 547–550, Nov., 1915.)—Winds being vector quantities, one of the most convenient methods of combining them to determine the monthly or other mean is by constructing a polygon. A simple form of apparatus is described and illustrated for drawing such a polygon readily from the individual readings by mechanical means, whereby the resultant can be obtained quickly without the employment of skilled labour. By the use of this apparatus resultant winds have been worked out for a number of stations in North-west Europe for the month of Jan., 1913. The mean movement in 24 hours is shown by arrows of appropriate length upon a map. It is commonly assumed that the warmth of this part of Europe in winter is due to the prevalence of SW. winds which blow directly from the Atlantic. The mean wind arrows for Jan., 1913, however, show a general SE. current over the greater part of the area. The author suggests that the true circulation from the Atlantic to Europe is as follows: The warmed air over the ocean rises and then flows south-eastward in an upper north-westerly current. When this strikes the high mountains of the Pyrenees, Alps, Carpathians, and Scandinavian ranges it is sufficiently cooled by contact with the cold mountain slopes to descend, and thence it flows back to its source on the

Atlantic as a south-easterly current. This idea of the circulation is supported by certain mountain observations to which the author refers. J. S. Di.

647. *New Units in Aerology.* **A. McAdie.** (Phys. Rev. 6. pp. 503–504 Dec., 1915. Abstract of paper read at Joint Meeting of the Am. Phys. Soc. and the Am. Assoc. for Advancement of Science, San Francisco, Aug., 1915.)—Recommends the use of certain units in meteorology, the chief departure from accepted practice being the suggested use of an absolute temperature scale in which 0° represents the absolute zero and 1000° the freezing-point of water under standard conditions. This would give a degree of more convenient size than the present Centigrade degree. J. S. Di.

648. *Illusions of the Upper Air.* **N. Shaw.** (Nature, 97. pp. 191–194, April 27, and pp. 210–213, May 4, 1916. Discourse delivered at the Roy. Inst., March, 1916.)—The author gives a brief review of the progress in meteorological theory in England since 1866, and then deals with the modern views as to the structure of the atmosphere according to the observations of the upper air. A short section is devoted to numerical calculations. L. H. W.

649. *Photometric Study of β Lyræ.* **J. Stebbins.** (Lick Observatory, Bull. 8. [No. 277] pp. 186–192, 1916.)—A photometric investigation of the variable star β Lyræ has been made with a sensitive rubidium photoelectric cell used in direct connection with a string electrometer hanging in gimbals on the end of the telescope. Connections were made practically as in the work of Guthwick and Prager, except that the negative electrode of the cell was connected to the electrometer thread. Observations extended over three cycles of the 12·92-day period. The main features of the light-curve agree with the visual curve previously known, but it is found that the changes are not exactly the same during successive epochs, the discordances being as large as 0·10 mag., and they have not been traced to instrumental error or variations of the comparison stars. The two maxima of the curve are about equal. At primary minimum there is distinct asymmetry, the decrease of light being more rapid than the increase. This difference extends as far as the maxima on each side of the primary minimum, with phases −2·95 days and +3·45 days respectively. The non-symmetrical features of the light-curve are ascribed to non-uniform surface intensity of the apparent discs of the component stars. C. P. B.

650. *Photometry of θ Aquilæ and σ Scorpii.* **J. Stebbins.** (Lick Observatory, Bull. 8. [No. 277] pp. 192–193, 1916.)—Observations were made with a rubidium photoelectric cell [see preceding Abs.] on stars of special interest. θ Aquilæ, mag. 3·37, spectrum A_0, is a well-known spectroscopic binary, with orbits determined by Harper and Baker. Using λ Aquilæ, mag. 3·55, spectrum A_0, as comparison star, no evidence was found of any kind of light-variation synchronous with the orbital variation.

In the case of σ Scorpii, mag. 3·08, spectrum class B_1, an extremely short period, 0·2468 day, has been found by Selga. There seems here to be evidence from the photometric tests of a variation of at least 0·03 mag. C. P. B.

651. *Translational Motion of Binary Stars.* **C. Luplau-Janssen.** (Astron. Nachr. No. 4828. Nature, 97. p. 131, April 6, 1916. Abstract.)—An investigation has been made of the distributions of the proper-motion vectors of a

number of double stars, with reference to their orbital planes. The proper motions were taken from the list by Boss, and reduced uniformly to their equivalents at a distance of 1 parsec, at which distance the adopted solar motion is represented by an angular displacement of 4·11″ per year. The resultant proper motions and the node lines lie in a common plane, and a chance distribution is indicated. C. P. B.

652. *Rotation of Planetary Nebulæ.* **W. W. Campbell** and **J. H. Moore.** (Lick Observatory, Bull. 9. [No. 278] pp. 1–5, 1916.)—Photographs of the spectra of the brighter planetary nebulæ have been obtained with a spectrograph of high dispersion with the special object of testing for evidence of rotation as shown by the Doppler-Fizeau effect. The present paper gives details of two cases where the evidence for rotation appears to be quite conclusive. Assuming that the max. rotational effect would be observed along the major axis of objects showing elliptical form, the slit was adjusted in this direction for the exposure.

Four spectrograms of N.G.C. 7009 were secured in Nov., 1915. From the measured displacements it is shown that the western portion of the nebula is being carried towards the earth, and the eastern edge, away, with a rotational velocity of the order of 6 km. per sec.

Five spectrograms of the planetary nebula N.G.C. 6543, another distinctly elliptical object, were obtained. In this case the motions found are somewhat complicated. The central portion of the nebula, to a diameter of about 6·7 secs. of arc, appears to be rotating about an axis in position-angle 180°, with a velocity of some 5 km. per sec. The outer portions seem to have greatly reduced velocities compared with the centre, but of a very complicated type. Some interesting speculations are made as to the possible densities of the two nebulæ. C. P. B.

653. *Wave-lengths of Green Nebular Lines.* **W. W. Campbell** and **J. H. Moore.** (Lick Observatory, Bull. 9. [No. 279] pp. 6–9, 1916.)—A special investigation of the positions of the green nebular lines has been made with the 3-prism Mills spectrograph remodelled to give minimum deviation at λ4950. Comparison spectra of titanium, hydrogen, and helium were used for determinations of wave-lengths, the data for helium being those resulting from interferometer observations. The adopted values are :—

N_1 Principal Nebular Line λ5007·02 (Rowland), λ5006·84 (International).
N_2 Second „ „ λ4959·09 „ λ4958·91 „

C. P. B.

654. *Wave-lengths of Green Nebular Lines.* **W. H. Wright.** (Lick Observatory, Bull. 9. [No. 279] pp. 9–10, 1916.)—On account of an error in the comparison lines used in 1901, a revision has been made of the former wave-lengths of the nebular lines published in 1902 (Ibid. No. 1. p. 153). The results are in very close agreement with those recently given by Campbell and Moore. [See preceding Abs.] C. P. B.

655. *Stereoscopic Observations of Orion Nebula.* **J. C. Solà.** (Comptes Rendus, 162. pp. 414–415, March 20, 1916.)—Photographs taken on 1915 Dec. 27, 1916 Jan. 27, and 1912 Jan. 27, have been examined with a stereogoniometer, and movements of certain brilliant parts appear to be discernible, of the order of 0·025 sec. of arc per annum, directed from east to west. On

the other hand, parts of the small nebula to the north of the main structure appear to have movements in the opposite direction. C. P. B.

656. *Cluster of Nebulæ in Cetus.* **M. Wolf.** (Astron. Nachr. No. 4838. Nature, 97. p. 148, April 13, 1916. Abstract.)—A rich cluster of about 50 nebulous objects has been found in the region R.A. = 0h. 49·0m.; $\delta = -20'$ (1885), slightly north of the 9·5 mag. star B.D. 2° 128. Other regions rich in small nebulæ are found in Coma Berenices and Virgo. C. P. B.

657. *Variation in the Solar Rotation.* **H. H. Plaskett.** (Astrophys. J. 43. pp. 145–160, March, 1916.)—Working with the large spectrograph of the Dominion Observatory at Ottawa it was found possible by refinements of instrumental conditions to obtain results practically free from instrumental error. The results are inconclusive as regards variation of rotation within a day, if the range be less than 0·1 km. There was good evidence of a cyclic variation extending over a month with range of 0·15 km. The mean of all the meaures indicated that the rotation in 1915 was 0·04 km. lower than it was in 1913. C. P. B.

658. *Formation of Sun-spots.* **F. Henroteau.** (Roy. Astron. Soc., M.N. 76. pp. 404–407, March, 1916.)—In connection with the results obtained by Cortie from a study of 3500 drawings of the sun at Stonyhurst, that the chief type consists of a double-spot, with a train of small ones between the two principal members of the group, and the discovery by Hale that the polarities of the two parts are in general of opposite sign, the author describes a series of his own observations in which he has detected the grouping of the small spots along elliptical curves. A suggestion is made that the appearance may be due to electrical discharges, and this links up with the view of Birkeland, who showed experiments in which discharges from a magnetised sphere *in vacuo* gave rise to phenomena greatly resembling sun-spots. The fact of sun-spots not being found in high solar latitudes might then be due to the electrons of one sign being repelled by the solar poles, and in the region of the equator by the electrons neutralising each other. The variation in sun-spot and solar activity would then be of the nature of a variation of the total solar potential. C. P. B.

659. *Elements of Minor Planets.* **H. C. Plummer.** (Roy. Astron. Soc., M.N. 76. pp. 378–390, March, 1916.)—An examination of the statistics of the elements of the minor planets show that the distribution in longitude of their perihelia can be represented by one harmonic term, the max. density being three times the minimum, and occurring in longitude 16·7°, about 4° from the perihelion of Jupiter. A frequency function has been found expressing the distribution of the minor planets with respect to the eccentricities of their orbits. The distribution of the ascending nodes is found to be irregular, and is represented by two harmonic terms of small amplitude. C. P. B.

660. *Stellar Magnitudes of Sun, Moon, and Planets.* **H. N. Russell.** (Astrophys. J. 43. pp. 103–129, March, 1916.)—After examining the results given by various investigators, the following magnitudes are suggested as acceptable for photometric discussion :—

Photographic magnitude of sun on Harvard scale = − 25·93
Visual „ „ = − 26·72
Visual „ full moon = − 12·55

The magnitudes of the planets are given for mean distance and various phase angles where these are presented; also for the moon under various phases. A further comparison gives the stellar magnitude of the standard candle at a distance of 1 metre as —14·18. C. P. B.

661. *Photometry of Eclipsing Variable RV Ophiuchi.* **R. S. Dugan.** (Astrophys. J. 43. pp. 130–144, March, 1916.)—New elements are given for the occurrences of computed eclipses of the star, containing a sine curve of small amplitude. During the total eclipse at primary minimum the star is 2·03 mag. fainter than at max. brightness, while the loss during the annular secondary eclipse is only 0·11 mag. Details are given of the computed relative brightnesses of the components, and attention is drawn to the fact that the light-curve is distinctly asymmetrical. C. P. B.

662. *Multiple System of λ Tauri.* **F. Schlesinger.** (Allegheny Observatory Publ. 3. 20. Nature, 97. pp. 169–170, April 20, 1916. Abstract.) —From a study of the line-of-sight motions it is concluded that the system of λ Tauri consists of three bodies, only one of which is bright enough for spectroscopic record. The presence of the others is deduced from the variations in the principal star's motion. Periods of 4 and 34·6 days are detected. C. P. B.

663. *Irregular Variable, T Tauri.* **G. E. Hale.** (Mount Wilson Solar Observatory, Report for 1915. Nature, 97. p. 189, April 27, 1916. Abstract.) —The irregular variable T Tauri has been found to be surrounded by an extensive atmosphere 4″ in diameter, showing the bright-line spectrum characteristic of Wolf-Rayet stars. The star's magnitude ranges between 10·3 and 13·2, and its spectrum is of type F_5. C. P. B.

664. *Eclipsing Binary, TT Aurigæ.* **C. Martin and H. C. Plummer.** (Roy. Astron. Soc., M.N. 76. pp. 395–400, March, 1916.)—During the past two years 88 exposures have been made on the region of this star with the 15-in. reflector at Dunsink, from which determinations of the photographic light-curve have been made. The observations are plotted in conjunction with the photometric values given by Balanowsky, and good agreement is shown except during the 6 hours covering the primary eclipse. C. P. B.

665. *Corrections for Velocities of Spectroscopic Binaries.* **F. Schlesinger.** (Astrophys. J. 43. pp. 167–170, March, 1916.)—In the cases of those spectroscopic binaries whose periods are sufficiently short to render the actual time taken in exposing on the spectrum of importance, it is evidently necessary to introduce appropriate corrections to allow for this interval. In the case of 12 Lacertæ, for example, the period is less than 5 hours, and the photographs of the spectrum require an exposure of 2 hours or more. Formulæ of reduction for determining the necessary corrections are provided, the values being at present confined to cases of circular orbits. C. P. B.

LIGHT.

666. *Parodi's Periscope.* (Engineering, 101. p. 348, April 14, 1916. From the "Rivista Marittima.")—Two diagrams are given of the instrument. No essential novelty is introduced from the optical point of view, except that a larger use is made of toroidal lenses. At the top of the tube is fixed a total-reflection toroidal prism, arranged so as to form both an achromatic converging lens and a total reflection prism, the curves of the various faces being determined so as to secure this result. The image reflected by the toroidal prism passes to the bottom end of the tube through a system of lenses. A total-reflection toro-prismatic system is fitted at the lower end of the tube, and thus the luminous rays from the horizon are so deviated that the image of the objects visible is given on a cylindrical screen placed round the lower prism system. The conditions of an observer who views the horizon direct are thus exactly reproduced, there being added the possibility of directing from the screen the principal problems relating to the course of the boat by combining the picture with a fixed index and the indications of a compass which are also projected on the screen. The compass has a transparent card, and is fitted in the conical cavity of the lower prism; it is lighted from the top, and the projection of the entire card is secured by means of a conical mirror and an annular lens. A. W.

667. *Theory of some Variable Neutral-tint Absorbing Screens.* **E. F. Kingsbury.** (Frank. Inst., J. 181. pp. 369–375, March, 1916.)—One of the most important and frequently-occurring problems in the design and use of optical and photometrical apparatus is how best to vary the intensity of a light flux easily and at the will of the operator. The present paper describes some work on neutral-tint absorbing screens made for this purpose. The three screens studied were (1) the opaque-line grating, (2) the perforated opaque plate, and (3) the parallel-wire grating. A parallel light-flux is always assumed. The first screen was made by ruling two gratings on glass with about 24 black lines per cm., then placing the two gratings and the lines parallel and slightly separated. When this screen is rotated about an axis parallel to the lines, the transmission varies at a rate determined by the separation of the surfaces. If ϕ is the angle of staggering of the lines and θ the rotation, T the distance apart of the gratings, and S the grating space, then the transmission $= 1 - (T/S)(\tan\phi - \tan\theta)$...(1), which holds for all values of θ, taking θ + or − on opposite sides of zero. For $\theta > \phi$ after (1) has passed through a maximum (1) becomes $1 + (T/S)(\tan\phi - \tan\theta)$. When the screen is rotated through 180° the corresponding expressions become $1 \mp (T/S)(\tan\phi + \tan\theta)$. The graph of the expression $1 - (T/S)(\tan\phi + \tan\theta)$ is given, and it has a point of inflection, which makes it approximately linear through that region.

The expression for the transmission through a grating made by drilling holes as closely as possible through a brass plate is rather complex. Graphs are given for various values of the quantity t = thickness/(radius of holes). The series of curves pass through practically a straight line for $t = 2\frac{1}{3}$, the only sharp bend being a short one for angles from about 35° to 40°. The parallel-wire grating was made by winding a rigid metal frame uniformly and tightly with soft-iron wire, soldering the edges, and then cutting away all the wires on one side. Great care is needed in handling such a screen, as the wires are easily bent; they must also be well blackened to avoid reflections. The screen while very simple mechanically, is not so useful as the others, as the transmission curve bends rapidly. A. W.

668. *Interference of Parallel and Crossed Rays.* **C. Barus.** (Science, 43. pp. 435–436, March 24, 1916.)—A continuation of previous work [Abs. 554 (1916)]. After perfecting the design of the earlier apparatus, and obtaining one free from transmission through glass, in which all the rays are reflected from metal surfaces only, definite evidence was obtained that the strands of interference patterns obtained are actually referable to the intersection of two grids, due to the two sodium lines respectively. One of the grids is retarded in rotational phase with respect to the other. By half-silvering the mirrors and providing a similar set beyond them, there should be no difficulty in bringing the interferences due to crossed rays, and to parallel rays, into the field of the telescope together. Mercury light, or other homogeneous light, would be needed to obviate the duplications of the sodium arc. In such a case the parallel fringes could be used after the manner of a vernier on the crossed fringes. A favourable feature of the reversed spectrum interferometer is the small displacement of micrometer per fringe, the sensitiveness being about twice that of the customary type of apparatus.

A. W.

669. *Use of Spectrophotometer with Jamin Refractometer.* **V. Posejpal.** (Böhm. Akad. Prag, 24. No. 17. 1915. Ann. d. Physik, 49. 4. pp. 419–432, March 24, 1916. Extract.)—Describes methods of employing a spectrophotometer in conjunction with a Jamin refractometer for various purposes, such as refraction and dispersion measurements, either absolute or relative.

A. W.

670. *Optics of Crystals.* **P. P. Ewald.** (Ann. d. Physik, 49. 1. pp. 1–38, Feb. 4, and 49. 2. pp. 117–143, Feb. 22, 1916.)—Following the method of Drude, the author postulates in a crystal the existence of electric doublets at the points of a space-lattice whose distances parallel to the three rectangular axes are proportional to *a*, *b*, and *c*. With this very simple foundation or model of a crystal he is able mathematically to derive dispersion formulæ in essential agreement with those of Lorentz and of Planck. It is found that this model structure is also able to represent the behaviour of crystals as to reflection and refraction of light and of Röntgen rays. E. H. B.

671. *Double Refraction of Vanadium Pentoxide Sols.* **H. Diesselhorst** and **H. Freundlich.** (Phys. Zeits. 16. pp. 419–425, Nov. 15, 1915.)—When a vanadium pentoxide sol is allowed to flow between crossed nicols in the direction of the axis joining the two nicols, a dark cross with concentric rings is seen, suggesting the figure given by a uniaxial crystal, the double refraction being positive in sign. When the sol is allowed to flow through a prism, in the direction of the edges, and light is refracted through the prism, two polarised rays are formed, the extraordinary ray being the more strongly refracted as in positive double-refraction in crystals. In accordance with Babinet's rule, the extraordinary ray is also more readily absorbed. Attention is directed to the close analogy between this "sol" and the "swarms" of anisotropic liquids such as *p*-azoxyanisol. T. M. L.

672. *Report of Committee on Glare. Projection and Focusing Screens.* (Am. Illum. Eng. Soc., Trans. 11. pp. 92–100, Feb., 1916.)

673. *Experiments on the Nature of the Photogenic Substance in the Firefly.* **E. N. Harvey.** (Am. Chem. Soc., J. 37. Chem. News, 113. pp. 220–221, May 12, 1916.)—A purely chemical investigation. L. H. W.

674. *Mechanical Equivalent of Light from a Tungsten Lamp.* **T. Peczalski.** (Comptes Rendus, 162. pp. 168–171, Jan. 24, 1916. Lum. Élec. 33. pp. 63–64, April 15, 1916.)—Describes experiments to determine the mechanical equivalent of the luminous radiation from a tungsten lamp. The lamp is enclosed in a glass-walled calorimeter containing a 2 % solution of $CuCl_2$. The rise of temperature of this solution is measured with the globe of the lamp (i) clear and (ii) blackened. If w and w' be the amounts of energy taken by the lamp per sec. in the two cases respectively to produce the same rise of temperature of the calorimeter, then $(w-w')/w$, corrected for the absorption curve of the solution in the red and infra-red, gives the ratio of visible to total radiation. This, combined with the candle-power of the lamp, gives 4·5 to 5 ergs/sec. as the mechanical equivalent of a lumen emitted from a tungsten lamp between wave-lengths of 0 and 0·65 μ.

J. W. T. W.

675. *Light Efficiency of Black-body Radiation and the Mechanical Equivalent of Light.* **A. R. Meyer.** (Elekt. Zeits. 37. pp. 142–145, March 16, and pp. 157–160, March 23, 1916.)—After a summary of the theory of black-body radiation a number of curves are reproduced and described exhibiting different relations. These are: (i) the relative amounts of energy which are radiated in different wave-lengths by a black body at various temperatures between 2000° and 10,000° abs.; (ii) from curve (i) and Ives' sensitivity curve of the eye, four curves are deduced giving the relative light values over the spectrum of the radiation emitted by a black body at various temperatures; (iii) from these curves another is deduced showing the radiation appreciated by the eye as light, expressed as a percentage of the total energy radiated within the visible spectrum (0·4 to 0·75 μ) by a black body at various temperatures; (iv) the variation with temperature of the intrinsic brightness of a black body, and (v) a curve giving, for various values of T, the corresponding value of n in the equation $(h_1/h_2)=(T_1/T_2)^n$; (vi) a curve showing the energy which must be radiated in the visible spectrum by a black body at various temperatures to produce (*a*) 1 Hefner candle, (*b*) 1 lumen; (vii) the ratio of luminous to total radiation of a black-body at various temperatures; (viii) from a combination of (iii) and (vii) the radiation appreciated by the eye as light expressed as a percentage of the total radiation throughout the spectrum; (ix) the efficiency (mean spherical Hefner candles per watt) of a black-body at various temperatures. This curve has a maximum at a temperature of about 6600° abs. with an efficiency of about 10·5 Hefner candles per watt; (x) a set of scales showing graphically the relation between watts per candle, candles per watt, and lumens per watt; (xi) the efficiencies of different types of lamps at different temperatures, and (xii) curves showing for different types of lamps the energy radiated in the visible spectrum expressed as a percentage of the total radiation. J. W. T. W.

676. *Radiations from Atoms and Electrons.* **J. J. Thomson.** (Engineering, 101. pp. 259–260, March 17; 282–284, March 24; 304–305, March 31;

828–829, April 7; 854–856, April 14, and pp. 880–882, April 21, 1916. Lectures delivered before the Roy. Inst.)—The author refers to his previous discussion as to the interpretation to be placed on the fact that Michelson had obtained interference between two rays of light when the difference in the lengths of the paths traversed exceeded half a million wave-lengths. Such a result would be impossible unless there were a very great regularity in the wave-train. If the latter had been subject to changes either in amplitude or phase interference would have been impossible. The further question had also been raised as to whether it were possible for the mercury atom to persist in uniform vibration long enough to furnish a uniform train of 540,000 vibrations. Had the train passed through a long series of glass prisms, the necessary regularity in the train of waves would have been secured even had the source been intermittent, because the regularities observed in light dispersed through glass are a question of the length of the path, and not of the character of the source. In the case of the mercury-vapour examined by Michelson, however, the length of the wave-path through glass was quite insufficient to produce the results observed, which could not, in short, be accounted for by dispersion of the ordinary kind. Nevertheless, there are reasons for believing that, after all, the remarkable regularity of Michelson's wave-train is not to be attributed to a regularity in the radiating atoms of Hg, but to the influence of the medium by which they are surrounded. In fact, the Hg-atoms active at any instant, are surrounded by Hg-vapour, and if this vapour has a very intense dispersive power for mercury light, the effect in question may be due to its action, and not to the character of the actual vibrators. In fact, the principles on which dispersion depend give reasons for concluding that if a mercury arc were in the presence of a substance having an inordinate dispersive power, even a thin layer might be capable of producing the regularity observed.

The usual relationship between the refractive index and the frequency of light vibration is that the higher the frequency the more refrangible the light. Plotting the refractive index for glass against the frequency yields, in fact, a quite commonplace curve. With some substances, however, an entirely different type of curve is obtained, and such bodies are said to show anomalous dispersion, and all of these bodies are capable of giving out on their own account a definite kind of light. If the graph connecting refractive index and frequency is plotted for such a substance, it is of ordinary form for low frequencies. But as we approach the frequency of the light the substance can emit, the refractive index rises rapidly and becomes theoretically infinite for the frequency in question. Since the velocity of propagation is inversely proportional to the refractive index, this velocity becomes zero at the place under consideration. For slightly higher frequencies, the square of the refractive index is negative, hence none of the light can get through the medium. At still higher frequencies the light begins to pass. In the neighbourhood of the special frequency of the light which the substance can emit, the dispersion is practically infinite, so that it is quite possible for a thin layer to produce the same effect on light of this wave-length as would a great length of path through glass.

To illustrate the character of the phenomena involved, the lecturer uses a model with which it is possible to show the transmission of waves of different frequencies through a system having a natural frequency of its own. The model consists of a series of balls hung from springs and joined by a horizontal wire. For one half of the series there are the balls only; for the other half each ball is secured to a frame, in which is mounted a heavy pendulum, and all these pendulums have the same definite time of swing. The unloaded balls represent the free ether, while those loaded with pendulums may represent a substance exhibiting anomalous dispersion.

The relations mentioned for the graph of such a substance were then experimentally exhibited with the model. It showed that very small changes in the frequency make enormous changes in the rate of propagation of the wave. Thus in the case of light in the neighbourhood of a point of anomalous dispersion, a 1 % difference in the frequency might alter the velocity of propagation 10 times.

The optical illustration of these relations was shown in an experiment with sodium-vapour after the mode due to R. W. Wood. For a particular wave-length the reflecting power of Na-vapour at a pressure under a thousandth of a mm. of mercury was as great as that of white paper. E. H. B.

677. *Band- and Series-spectra of Hydrogen.* **J. Stark.** (Ann. d. Physik, 49. 2. pp. 179–200, Feb. 22, 1916.)—Describes research on the carriers for the band and series-spectra of hydrogen. As a result of the experiments and discussion the following conclusions are arrived at:—(i) The H series and the H band spectra have different carriers, but both carriers have the same mass as the hydrogen atom; (ii) the carrier for the series spectrum is the positive atomion; (iii) the neutral hydrogen atom is the carrier for the band spectrum. (iv) The results under (i), (ii) and (iii) in conjunction with the fact that the hydrogen band-lines show no marked Doppler-effect in canal rays, lead to the conclusion that the neutral hydrogen atom does not appear in any considerable numbers as displaced particles in hydrogen canal rays. This conclusion can also be reached in another way. (v) The origin of the stationary series-lines and band-lines is to be found in the impacts of kathode and canal rays. (vi) The band-lines in hydrogen canal rays are not excited by the impacts of the secondary kathode rays, but are directly due to the impacts of the canal rays. A. W.

678. *Structure of Broadened Spectrum Lines.* **T. R. Merton.** (Roy. Soc., Proc. 92. pp. 322–328, April 1, 1916.)—An important case of broadening is that which occurs when condensed discharges are used. The author has investigated the effect of such discharges on helium and hydrogen at pressures of about 1 mm. by means of a Fabry and Perot interferometer. The apparatus and method have previously been described. The main results, which are in agreement with those of other investigators, are as follows:—(i) Whilst with uncondensed discharges the limiting order of interference, N, is constant for different lines belonging to the same element, this is no longer the case when condensed discharges are used. (ii) For a given series the value of N becomes less as the series number of the line increases, *i.e.* the more refrangible lines undergo the greatest broadening. (iii) Different series are affected to a different degree. (iv) The magnitude of the broadening decreases as the pressure decreases. Arguing from these results it is concluded that the broadening is not due to a rise of temperature at each impulse of the condensed discharge, and it appears doubtful whether the broadening can be due to the movement of the luminous particle as a whole, but rather that it must be referred to processes more intimately connected with the problem of radiation. It also seems improbable that the potential-fall in the capillary of the tube would be great enough to give rise to any considerable broadening. An experiment was performed which apparently shows that any broadening effect due to the field of the discharge tube is

negligible, but rather that the broadening is due to the electric field of neighbouring particles, as assumed by Stark. In accordance with this is the fact that the mean distance between the particles will be diminished by pressure-increase; also an increase in the number of charged particles will result from the considerable current density which obtains when condensed discharges are employed, both these circumstances giving rise to a broadening of the spectrum lines. The distribution of intensity to be expected, on the above view, when the hydrogen lines are broadened is next considered, and an attempt was made to study experimentally the distribution in H_α, H_β, and H_γ. It is believed that the method adopted will yield an accurate quantitative measurement of the intensity distribution, and by means of it the qualitative structure of broadened lines can at once be seen. A neutral-tinted wedge of density graded from 0·2 to 4·2 was mounted vertically on the slit of a spectrograph and the slit was illuminated with light from the source studied, care being taken, before the wedge was put into position, that the required length of the slit was evenly illuminated. Under these circumstances the spectrum appears to consist of lines, bright at the points corresponding to the thin end of the wedge, and gradually fading off with increased density. It is evident that, from the apparent lengths of two lines, their relative intensities can be calculated, provided that they are so close together that errors due to the variation of the sensibility of the plate to different wave-lengths do not arise. A broadened line gives a wedge-shaped image on the plate, the apex corresponding to the max. of intensity in the line, and, from the shape of these wedges the intensity at different distances from the maximum can be calculated. The method consists in picking out points of equal density at different wave-lengths and determining the thicknesses of the wedge to which they correspond. Points of equal density must indicate equal illumination, since they are exposed for the same time and subjected to the same treatment. The method is thus unaffected by the eccentricities of the photographic plate, and it is only necessary to assume that there is one particular density that can be recognised at different points. For the investigation of the hydrogen lines, which were produced by the passage of condensed sparks through hydrogen at atmospheric pressure, the dispersion of a single-prism spectrograph was sufficient. A number of plates were taken, one of which is reproduced, and the results were also confirmed by visual observation. H_α consists of a strong maximum, falling off rather rapidly, and apparently regularly. In H_β the intensity falls off much less rapidly, and there is a distinct minimum at the centre of the line, which appears to be a hazy doublet. H_γ has a bright central line with very wide nebulous wings. The observed effects appear to be in close agreement (at least qualitatively) with the intensity distribution deduced from Stark's observations of the electrical resolution of the lines, and appear strongly to support Stark's view of the origin of broadening. Quantitative measurements, with improved experimental arrangements, are in progress. [See also Abs. 1190 (1912), 555 (1915).] A. W.

679. *Fluorescing Sodium Uranyl Phosphate.* H. L. Howes and D. T. Wilber. (Phys. Rev. 7. pp. 394–396, March, 1916.)—In an early article by C. G. Stokes on the ultra-violet spark spectra of the metals mention is made of a powerfully fluorescent screen made from the phosphate of uranium. Since the ordinary phosphate is only slightly fluorescent it seemed of interest to prepare the phosphate employed by Stokes and to determine the nature of its fluorescence. The Stokes method of preparation is to treat the ordinary phosphate with a solution of phosphoric acid and sodium or ammonium phosphate. The non-fluorescent salt, which is a yellow amorphous insoluble powder, is changed into the fluorescent double salt as the mass dries out. The chemical problem is to find the composition of the fluorescent double salt. To ascertain the rôle played by phosphoric acid, several specimens were prepared by mixing increasing amounts of phosphoric acid with sodium uranyl phosphate, the spectrum in each case being carefully examined. From the results obtained it is shown that Stokes employed, for the purpose of making his fluorescent screen, one of the best substances he could have obtained. A. B. W.

680. *High-frequency Spectra (K-series) of the Elements Cr to Ce.* **M. Siegbahn** and **M. Stenström.** (Phys. Zeits. 17. pp. 48–51, Feb. 15, 1916.)—A table of wave-lengths obtained for the elements Cr, Mn, Fe, Co, Ni, Cu, Zn, Ce is given, and a comparison made between experimental values and those of Moseley. The values obtained in this investigation are consistently about 1 % less than those of Moseley. The authors have used the value log $2d = 0{\cdot}75035$ given by Bragg for rock-salt, whereas Moseley used potassium ferrocyanide as his analysing crystal ($d = 8{\cdot}454 \times 10^{-8}$ cm.). A small change in the value of the constant would easily account for the divergence between the two sets of results. A. B. W.

681. *High-frequency Spectra (L-series) of the Elements Polonium, Radium, Thorium, and Uranium.* **M. Siegbahn** and **E. Friman.** (Phys. Zeits. 17. pp. 61–62, March 15, 1916.)—In an earlier paper [Abs. 440 (1916)] the results were given of an investigation of the L-series of the elements from Ta to Bi. At least 11 groups of lines were determined. The measurements are now extended to the elements Po, Ra, Th, and Ur. In the case of polonium (deposited electrolytically on copper), two characteristic lines (α_1, β_1) were observed, and in addition a number of other lines probably due to impurities. Using 0·1 mgm. of $RaBr_2$, to obtain the Ra spectrum, only a very weak α-line could be obtained. Both Th and Ur gave multiple-line spectra. The values of the wave-lengths, relative intensities, etc., of the various lines are tabulated. Plotting the values of $1/\lambda$ against atomic numbers it is found that the new α_2, α_1, and β_2-values fall exactly on the same straight line as the old values, whilst the remainder ($\beta_1, \beta_3, \gamma_1, \gamma_2, \gamma_3$) are too high. A. B. W.

682. *Recent Work on X-rays and Crystals and its Bearing on Chemistry.* **W. H. Bragg.** (Chem. Soc., Trans. 109. pp. 252–269, March, 1916.)—A brief historical survey of the work on this subject, and an outline of the later developments and applications of this work to chemistry—*i.e.* "in the study of various forms of crystals and of the arrangement of atoms in the molecules; in the observation of the changes which occur when one atom is substituted for another; in the study of allotropic forms; in the light which may be shed on the crystalline features of metallurgy; in the power we acquire of studying quantitatively the motions of the atoms with heat; in the wholly different field of the study of X-rays themselves; in what the X-rays tell us of the nature of the atomic structure from whence they came,—in all this, there is an immense field of work." A. B. W.

683. *X-ray Spectroscopic Methods without Slit.* **H. Seemann.** (Ann. d. Physik, 49. 4. pp. 470–480, March 24, 1916.)—Methods are described in which a sharp-line X-ray spectrum can be produced by a plane-parallel beam of

rays falling on the edge of a crystal and subsequently on the photographic plate. No slits are necessary in the arrangement described.

Using these methods experiments have been made to determine the thickness of the crystal layer which is effective in producing interference effects, as well as on the factors affecting the breadth of spectral lines. The thickness has been roughly determined. The complex line spectrum previously found by the author [Abs. 1058 (1915)] is now shown to be unreal. An explanation is given. A. B. W.

684. *Mica X-ray Spectrometer.* **W. S. Gorton.** (Phys. Rev. 7. pp. 334–340, March, 1916.)—De Broglie and Lindemann [Abs. 1268 (1914)], and Rohmann [Abs. 456 (1915)], have described an X-ray spectrometer employing mica as analyser. This spectrometer consists essentially of a sheet of mica, bent to a cylindrical shape, on which a beam of X-ray falls. The various components of the beam are reflected at different angles and are received on a photographic plate. In the instrument used in the present work a beam having angle of 5½° allows a range of 45¼° in the angles of reflection. A study has been made of the properties of the instrument and on the structure of mica. The results indicate that the unit in the structure of mica would seem to be a parallelopiped containing atoms spaced in such a way as to form sets of planes having the interplanar distances $1{\cdot}93 \times 10^{-8}$ and $3{\cdot}19 \times 10^{-8}$ cm. A. B. W.

685. *Scattering of X-rays and Atomic Structure.* **C. G. Barkla** and **J. G. Dunlop.** (Phil. Mag. 31. pp. 222–232, March, 1916.)—The conclusions drawn as a result of the experiments described are summarised as follows:—The scattering of X-rays of very short wave-length by equal masses of various substances varies only little with the atomic weight of the scattering element. There is a slight increase of the mass scattering coefficient with an increase in the atomic weight of the scatterer. (Elements of low atomic weight have previously been shown to scatter to approximately the same extent mass for mass, not only X-radiation of short wave-length, but X-radiation of any wave-length between widely separated limits).

The increase of the scattering with the atomic weight of the scattering substance becomes more marked with X-radiation of greater wave-length, until for long waves it becomes very considerable; that is, the heavier elements scatter much more, mass for mass, than light elements when the radiation is of long wave-length ("soft"). Thus the intensity of X-radiation of given wave-length scattered by equal masses of different elements increases with the atomic weight of the element, and the intensity of X-radiation scattered from a given material increases with the wave-length of the radiation of given intensity. These variations are inappreciable among elements of low atomic weight for radiations of wave-length which may be regarded as ordinary Röntgen radiation.

In conclusion, a discussion is given of the theoretical bearing of these observations on the problem of atomic structure. A. B. W.

686. *Symmetry of Röntgen Patterns of Monoclinic Crystals.* **H. Haga** and **F. M. Jaeger.** (K. Akad. Amsterdam, Proc. 18. 7. pp. 1201–1205, 1916.)—The paper contains a collection of results obtained by radiating through parallel plates of monoclinic crystals. As representatives of the different classes of symmetry the following crystals have been studied: (*a*) Of the monoclinic-sphenoidical class—dextrogyratory tartaric acid, cane sugar and dextrogyratory rhamnose. (*b*) Of the monoclinic-domatic class—scolezite. (*c*) Of the monoclinic-prismatic class—gypsum, epidote, amphibole, and augite.

In every case the Röntgen patterns show a symmetry quite in accordance with the conclusions drawn from the proposed theory of the diffraction-phenomenon.

An interesting explanation is given of the presence of a bright ring round the central spot observed in some of the patterns. A. B. W.

687. *Experiments to Detect Refraction of X-rays.* **C. G. Barkla.** (Phil. Mag. 31. pp. 257–260, April, 1916.)—On the simple theory of dispersion the refractive index (μ) of a substance is given by an expression of the form—

$$\mu^2=1+\sum\frac{Ne^2}{\pi m(n_0^2-n^2)},$$

where N is the number, per unit volume, of particles of mass m, charge e, and vibration frequency n_0, and n is the frequency of the incident radiation. If then the theory were applicable even in a modified form to radiation of such short wave-length as that in X-radiation, it seems just possible that by careful experiment refraction might in some cases be detected. Experiments have been made previously by a number of investigators, but they have not been of such a kind as, with our present state of knowledge, to justify any hope of success. In the present experiments a narrow beam of X-rays was passed through two refracting prisms of KBr, with refracting edges vertical but with their bases on opposite sides of the transmitted radiation. After passing through the prisms the rays fell on a photographic plate placed about 1½ metres away. No evidence of refraction was obtained. A. B. W.

688. *Genesis and Absorption of X-rays.* **J. J. Thomson.** (Engineering, 101. pp. 406–407, April 28, 1916. Lecture delivered before the Roy. Inst., April 14, 1916.)—As introduction, an outline is given of the principal features observed in the case of emission and absorption of the visible part of the spectrum. The analogous cases for X-rays are subsequently considered. In particular, reference is made to the Röntgen radiation lying between the visible light and the "medical rays" (or "ordinary" X-rays). The difficulty in this region consists mainly in that the waves are too short to be examined by the aid of gratings and too long for making use of the spacings of the planes in which atoms are grouped in crystals. A description follows of the production and absorption of this type of radiation, and an interesting outline of its peculiarities and properties. A. B. W.

RADIO-ACTIVITY.

689. *Long-range α-Particles from Thorium.* **E. Rutherford** and **A. B. Wood.** (Phil. Mag. 31. pp. 379–386, April, 1916.)—In the course of an examination of a strong source of the active deposit of thorium by the scintillation method, a few bright scintillations were observed, which were able to penetrate through a thickness of matter corresponding to 11·3 cm. of air at 760 mm. and 15° C. These scintillations were undoubtedly due to α-particles of greater velocity than any previously known. The number of these long-range particles decreased exponentially with the time, falling to half value in 10·6 hours—the normal period of decay of the active deposit of thorium. Further investigation has shown that the long-range particles

are apparently divided into two homogeneous groups of max. ranges 10·2 and 11·3 cm. respectively. The number of these α-particles is about 1/10,000 of the total number emitted from ThC, two-thirds of the number having a range of 11·3 cm. These α-particles are believed to have their origin in the transformation of ThC, and the results indicate that the atoms of ThC can break up in three and probably four distinct ways with the emission of four characteristic groups of α-particles of ranges 5·0, 8·6, 10·2, and 11·3 cm. A. W.

690. *Constants of Radio-activity.* **G. L. Wendt.** (Phys. Rev. 7. pp. 389–398, March, 1916.)—This paper contains the subjoined table of the fundamental radio-active constants.

Substances.	λ (sec.$^{-1}$).	T Half-life Period.	Chemical Group.	Rays.	Range in cm. at 15° C.	μ_β (Al) (cm.$^{-1}$).	μ_γ (Al) (cm.$^{-1}$).
Uranium 1	$4·3 \times 10^{-18}$	5×10^9 yrs.	6	α	2·50	—	—
Uranium X_1	$3·3 \times 10^{-7}$	24·6 d.	4	β	—	510	24 ; 0·70 ; 0·140
Uranium X_2	0·01	1·15 min.	5	β	—	14·4	
Uranium 2	$1·1 \times 10^{-14}$	2×10^6 yrs. ?	6	α	2·90	—	—
Uranium Y	$7·5 \times 10^{-6}$	25·5 hrs.	4	β	—	300	—
Ionium	$2·2 \times 10^{-13}$	10^5 yrs.	4	α	3·11	—	—
Radium	$1·26 \times 10^{-11}$	1730 yrs.	2	α, β	3·30	200	354 ; 16 ; 0·27
Ra Emanation	$2·085 \times 10^{-6}$	3·85 d.	0	α	4·16	—	—
Radium A	$3·85 \times 10^{-3}$	3·0 min.	6	α	4·75	—	—
Radium B	$4·33 \times 10^{-4}$	26·7 min.	4	β	—	75	230 ; 40 ; 0·51
Radium C_1	$5·93 \times 10^{-4}$	19·5 min.	5	α, β	—	13·5	0·115
Radium C_2	$8·3 \times 10^{-3}$	1·4 min.	3	β	—	—	—
Radium C′	$7 \times 10^{+5}$	10^{-6} sec. ?	6	α	6·94	—	—
Radium D	$1·39 \times 10^{-9}$	15·83 yrs.	4	β	—	130	45 ; 0·99
Radium E	$1·66 \times 10^{-6}$	4·85 d.	5	β	—	43·3	like RaD
Polonium (RaF)	$5·90 \times 10^{-8}$	136 d.	6	α, β?	3·84	—	585
Thorium	$1·2 \times 10^{-18}$	$1·8 \times 10^{10}$ yrs.	4	α	2·72	—	—
Mesothorium 1	$4·0 \times 10^{-9}$	5·5 yrs.	2	—	—	—	—
Mesothorium 2	$3·1 \times 10^{-5}$	6·2 hrs.	3	β	—	30	26 ; 0·116
Radiothorium	$1·09 \times 10^{-8}$	2·02 yrs.	4	α	3·87	—	—
Thorium X	$2·20 \times 10^{-6}$	3·64 d.	2	α	4·30	—	—
Th Emanation	0·0128	54 sec.	0	α	5·00	—	—
Thorium A	5·0	0·14 secs.	6	α	5·70	—	—
Thorium B	$1·8 \times 10^{-5}$	10·6 hrs.	4	β	—	110	160 ; 32 ; 0·36
Thorium C_1	$1·9 \times 10^{-4}$	60 min.	5	α, β	4·80	—	
Thorium D	$3·7 \times 10^{-3}$	3·1 min.	3	β	—	16·3	0·096
Thorium C′	$7 \times 10^{+10}$	10^{-11} sec. ?	6	α	8·60		
Actinium	1×10^{-10}	200 yrs. ?	3	α ?	3·56	—	—
Radio-actinium	$4·25 \times 10^{-7}$	18·88 d.	4	α, β	4·2	170	25 ; 0·190
[Radio-actinium′] ?	$3·2 \times 10^{-6}$?	60 hrs. ?	?	α ?	4·61	—	—
Actinium X	$7·6 \times 10^{-7}$	11·4 d.	2	α	4·26	—	—
Act. Emanation	0·18	3·9 sec.	0	α	5·57	—	—
Actinium A	350	0·002 sec.	6	α	6·27	—	—
Actinium B	$3·2 \times 10^{-4}$	36·1 min.	4	β	—	soft	120 ; 31 ; 0·45
Actinium C_1	$5·37 \times 10^{-3}$	2·15 min.	5	α, β ?	5·15	—	—
Actinium D	$2·26 \times 10^{-3}$	4·71 min.	3	β	—	28·5	0·198
Actinium C′	700	0·001 sec.	6	α	6·45	—	—

A catalogue of general relations involving the above-mentioned constants is also included. A. B. W.

691. *Atomic Weight of Radium Emanation (Niton).* **S. C. Lind.** (Science, 43. pp. 464–465, March 31, 1916.)—A comment on the difference in values of the atomic weights of RaEm as appearing in the International Atomic Weights table (222·4) and as deduced from radio-active data (222·0, assuming the accuracy of Hönigschmid's determination of the atomic weight of Ra, viz. 226·0). The author considers there is no justification for retaining the old value, 222·4, in the atomic table. A. B. W.

692. *Variation of Radio-activity of Hot Springs.* **A. Steichen.** (Phil. Mag. 31. pp. 401–403, April, 1916.)—Measurements of the radio-activity of hot springs at Tuwa (Bombay Presidency) show that it is less when the spring yields much water than when the supply of water is relatively small. This behaviour of the spring is not necessarily in contradiction to the results of Ramsey (Ibid. 40. pp. 815–818, 1915.) The results can be explained by local conditions. A. B. W.

693. *Monazite, Thorium, and Mesothorium.* **K. L. Kithel.** (Bureau of Mines, Techn. Paper No. 110 [32 pp.] Washington, 1915.)—A description is given of the occurrences of monazite in the United States, the uses to which its products can be put, and the methods of mining and treatment. The investigation has been suggested by the Bureau of Mines for the purpose of aiding in the efficient utilisation of radio-active materials, and the subject is treated mainly from the commercial standpoint.

For further particulars the original paper should be consulted. A. B. W.

694. *Absorption and Diffusion of Fast Kathode Rays (β-Rays) in Gases and Vapours.* **E. Friman.** (Ann. d. Physik, 49. 4. pp. 373–418, March 24, 1916.)—The paper describes an investigation on the absorption and diffusion of the β-rays from UrX in gases and vapours. The experimental arrangement is devised so as to eliminate all outside influences in the determination of the magnitude of the absorption, especially the error due to the diffusion of the radiation. The absorption measurements have been made by two methods differing only in principle, viz. the method of "distance-variation" and the method of "pressure-variation." The first method was found to be most suitable in the determination of absolute values of the absorption coefficients; the second method was applied in the determinations of the relative absorptive powers of different gases. The value of the absorption coefficient for the β-rays from UrX, in air at N.T.P. was found to be 0·0047 cm.$^{-1}$. The absorption in the cases of the gases oxygen and CO_2, and the vapour of acetone, is approximately proportional to the density. The halogen compounds (isobutylchloride, chloroform, carbon tetrachloride, ethyl bromide, methyl iodide), on the other hand, show marked deviations from such proportionality.

The quantitative determination of the diffusion of the radiation in the above-mentioned gases and vapours supports the theory developed by Lenard. The diffusion factors obtained are determined, as in the previous case of absorption, by the density of the gas through which the rays are passing. The halogen compounds in this case also show considerable deviations, increasing with atomic weight, again like the absorption coefficients. A. B. W.

HEAT.

695. *Thermal Conductivity of Air: Micro-manometers with Electrical Heating.* **E. Marini and M. Blache.** (N. Cimento, 11. pp. 95–117, Jan.–Feb., 1916.)—Continuing the work of Knudsen [see Abs. 899 (1911)] the authors have made experiments on the thermal conductivity of air at pressures below 0·1 mm. of mercury in order (1) to determine the influence of the residual gas in the flask containing the metallic filament when the temperature is very high, and (2) to construct a manometer of practical use. The results of the measurements show (1) that the quantity of heat q, traversing a gas enclosed between walls at different temperatures, is proportional to this difference of temperature even for small intervals, and (2) that q is proportional to the pressure p, if very thin wires are used in the experiments. When, however, it is desired to render the arrangement more sensitive or to pass a larger current through the galvanometer, it becomes necessary to use thicker wires in order to avoid excessive heating; in such cases the law of proportionality between q and p no longer holds, and, in the instance studied by the authors, the curves obtained are not in agreement with the experimental law deduced by Knudsen for very thin wires at very high pressures. Advantages possessed by these manometers over that of MacLeod are their applicability to vapours and their continuous record of the variation of the pressure; their employment seems, therefore, useful provided they are compared with the MacLeod instrument. One defect of all such micromanometers with electric heating lies in the necessity for standardising them not only for air but also for any other gas with which they are used, owing to the variation with different gases (1) of the specific heats at constant pressure and volume and therefore of the coefficient of conductivity and (2) of Knudsen's coefficient of accommodation, which is not easily determined experimentally. T. H. P.

696. *Experiments on the Flow of Heat in Metal Sheets.* **S. Skinner.** (Phys. Soc., Proc. 28. pp. 119–122; Disc., 122–123, April 15, 1916.)—If a sheet of tinned iron be heated locally by means of a Bunsen burner or blowpipe the tin is melted for a certain distance from the heated region. On allowing the sheet to cool the re-solidified tin is separated from the unmelted tin by a very sharp line of demarcation. This line gives us the equi-temperature curve corresponding to the melting-point of tin. By pushing the heating to a greater or less extent a series of such equi-temperature curves can be obtained for a sheet of any particular shape heated at any given point. The cases shown illustrated the flow of heat into a rectangular plate from a heated tongue; into a circular disc from a heated tongue; round the corner of an L-shaped strip and into the vanes of an air-cooled cylinder. The results are shown to be closely analogous to the flow of electricity in similarly shaped conductors. AUTHOR.

697. *Ratio of Specific Heats of Nitrogen.* **F. A. Schulze and H. Rathjen.** (Ann. d. Physik, 49. 4. pp. 457–469, March 24, 1916. Extract of Dissertation, Marburg.)—The experiments described form a part of a series of similar researches for the determination of c_p and $K = c_p/c_v$ for various gases.

Results have already appeared describing determinations of c_p for helium, hydrogen, nitrogen, air and oxygen, and of $K = c_p/c_v$ for oxygen. In the present investigation an accurate determination is made of c_p/c_v for nitrogen, employing the sound-velocity method. The relative wave-lengths of sound of a given frequency are determined in air (free from water-vapour CO_2, etc.) and in purified nitrogen, various corrections being applied. The mean value of $K = c_p/c_v$ for nitrogen at N.T.P. is given as 1·4144 ± 0·0002. Using this result, and the value of c_p for nitrogen (= 0·2429, found previously), the value $J = 4{\cdot}193 \times 10^7$ ergs is deduced. A. B. W.

698. *Determination of the True Temperatures of Solid Bodies from the Intersection Point of the "Logarithmic Isochromates" in the Visible Spectrum.* **E. P. Hyde.** (Ann. d Physik, 42. 2. pp. 144–148, Feb. 22, 1916.)—The paper is a criticism of a paper by Elisabeth Benedict under the same title [see Abs. 1699 (1915)]. It was there asserted that if the "logarithmic isochromates," or straight lines connecting log E_λ and 1/T of a black or grey body, obtained by measurements with a comparison source at constant temperature, intersect at a point, then the energy distribution in the spectrum of the comparison lamp is the same as that of the black or grey body. Hence it follows that the comparison lamp between particular limits of temperature radiates as a grey body, and its true temperature, as well as that of the black or grey body, is that given by the intersection point. If the "logarithmic isochromates" do not intersect at a common point, this divergence points to selective radiation.

While agreeing with the latter conclusion, Hyde points out that it is easily possible that the radiating source is wholly selective, that is, it may possess in the blue end of the spectrum a far greater power of emission than in the red end. Nevertheless the character of the selectivity may be of such a kind that a black or grey body at a certain temperature possesses exactly the same energy-distribution in the visible spectrum. The true temperature of the comparison source would be in this case quite different from that of the black or grey body. Experiments with a tungsten lamp run at a particular voltage verify these conclusions. T. B.

699. *Studies of Instruments for measuring Radiant Energy in Absolute Value. An Absolute Thermopile.* **W. W. Coblentz and W. B. Emerson.** (Bureau of Standards, Bull. 12. pp. 503–551, 1916 [Sci. Papers, No. 261].)—One of the chief necessities in the measurement of radiant energy is an instrument that shall give reliable absolute measurements. The object of the paper is the examination of an instrument designed for this purpose, in order to test its reliability in general radiometric work, *e.g.* as a radiation pyrometer. A by-product of the investigation is the evaluation of the so-called Stefan-Boltzmann constant (σ) of total radiation. The radiometric "receiver" which is the subject of the present investigation consists of a very thin strip of metal (Pt, manganin, or "therlo") coated with lampblack, etc., behind which, at a distance of 2 or 3 mm., is a bismuth-silver thermopile. The "receiver" can be used in three ways: (1) to absorb radiant energy; (2) as a source of radiant energy (by heating it electrically); (3) as a standard source of radiation for testing the sensitivity of the thermopile and galvanometer. Thirteen "receivers" of different material and dimensions were tested with satisfactory results, the values for σ—uncorrected for reflection from receiver—agreeing well with those of previous observers, with a mean value of about $5{\cdot}7 \times 10^{-12}$. The instrument has now been placed in an evacuated

enclosure, and radiation measurements are to be made at certain fixed temperature points as defined by the melting-points of metals such as Au, Ag, and Pd. In this way it is hoped to eliminate the various sources of error met with in such measurements, and to obtain a reliable value of the constant σ. T. B.

700. *Ignition of Gases by Impulsive Electrical Discharge.* **W. M. Thornton.** (Roy. Soc., Proc. 92. pp. 381–401, May 6, 1916.)—Consideration of the ignition of gases by impulsive discharge first as a function of sparking distance shows that the shorter the distance the greater the spark, so that the volumes of the least igniting sparks are, in a typical case, the same for all spark-lengths. Ignition may occur with intense momentary brush discharge, generally with the true disruptive spark. The products of combustion are found to be ionised and to carry a positive charge. The gases examined were mixtures with air of hydrogen, methane, propane, pentane, ethylene, acetylene, carbon monoxide, cyanogen, coal gas, and a mixture of hydrogen and methane in equal volumes. With hydrogen, propane, pentane, and CO, the difficulty of ignition increases gradually as the percentage of oxygen is reduced, methane is ignited by the same spark whatever the percentage of gas may be, ethylene and cyanogen have the stepped atomic type of ignition, and ethylene is more inflammable in rich mixtures. With hydrogen and methane in equal volumes, the ignition is of the type of that of methane and of the magnitude of that of hydrogen.

As regards the limits of inflammability of the paraffins, the upper limit is reached when the volume of combustible gas present is double that in the mixture corresponding with perfect combustion, and the lower limit when the volume of oxygen is twice that required for perfect combustion less one atom to the molecule of combustible gas. In the case of coal gas, ignition takes place through methane. A brief survey is given of the four types of electrical ignition, covering the whole range from the most rapid to the slowest rate of discharge from the poles. The results obtained furnish direct evidence in support of the view that ignition begins by ionisation of the oxygen present in the mixture. T. H. P.

701. *"Centre of Gravity" and "Effective Wave-length" of Transmission of Pyrometer Colour-screens.* **P. D. Foote.** (Bureau of Standards, Bull. 12. pp. 483–501, 1916 [Sci. Papers, No. 260].)—The effective wave-length of the colour-screens used with optical pyrometers shifts along the spectrum as the temperature of the source sighted upon changes. This effective wave-length has been generally taken as the so-called centre of gravity of the luminosity curve, but Hyde, Cady, and Forsythe have more correctly defined the effective wave-length of a pyrometer glass between any two temperatures, as that wave-length for which the ratio of the radiation intensities corresponding to the two temperatures exactly equals the ratio of the integral transmitted luminosities for the same two temperatures. In this paper the difference between the centre of gravity and the true effective wave-length as defined above is discussed mathematically, and it is shown that the true effective wave-length at any temperature is the centre of gravity of the curve $L_\lambda/\lambda = f(\lambda)$, where L_λ is the luminosity at wave-length λ of the transmitted light. It is further shown that when an absorption glass, Nicol prisms, or sector disc is used with a pyrometer employing light which is not strictly monochromatic (such as the Holborn-Kurlbaum instrument) for the object of reducing the brightness of the sources sighted upon, the relation between the

true temperature θ and the measured temperature S is of the form $1/\theta - 1/S = A$, where A has heretofore been considered a constant. Actually, it is shown, A varies rapidly with change in temperature of the source. The consideration of A as a constant may introduce errors as great as 40 or 50 deg. at 3500° if the absorption device is calibrated in the usual manner. When two or more absorption glasses are used together it is not permissible to assume that the value of A for the entire system is equal to the sum of the values of A for the glasses used separately. It is shown that the combination of a sector disc and absorption glass gives a value of A which is practically independent of θ. J. W. T. W.

702. *Luminosity of a Black Body.* **P. D. Foote and C. O. Fairchild.** (Bureau of Standards, Bull. 13. pp. 137–145, 1916 [Sci. Papers, No. 270].)—The luminosity of a radiator is defined as the integral from 0 to ∞ with respect to λ of the product of visibility (V) and energy (J) of the radiating source, *i.e.* $L = \int_0^\infty VJ\,d\lambda$, where $V = f(\lambda)$ is given by the experimental determinations of Ives, Nutting, and Hyde and Forsythe, and $J = c_1\lambda^{-5}e^{-c_2/\lambda\theta}$ (Wien's law). The effective wave-length λ_L of the luminosity has been defined analytically by Foote [see preceding Abs.] as $\lambda_L = \int_0^\infty VJ\,d\lambda \Big/ \int_0^\infty (VJ/\lambda)\,d\lambda$. From this expression and that for L given above it is seen that—

$$d\log L/d\theta = (c_2/\theta^2)\int_0^\infty (VJ/\lambda)\,d\lambda \Big/ \int_0^\infty VJ\,d\lambda = (c_2/\theta^2)/\lambda_L.$$

If now the expression for λ_L be assumed to be of the form—

$$\lambda_L = a + b/\theta + c/\theta^2 + \ldots$$

where $a, b, c, \ldots$ are dimensional constants, then this expression for λ_L may be substituted in the above value of $d\log L/d\theta$, and hence $L = f(\theta)$ may be obtained by integration. The quantity λ_L is the value of the λ co-ordinate of the centre of gravity of the curve JV/λ *versus* λ, and in the present work values of λ_L for temperatures ranging from 1000° to 7000° abs. were obtained directly from the JV/λ *versus* λ curves by means of the Amsler Integrator No. 1. The possible forms of the luminosity equation are as follows:—Case I. $\lambda_L = a$, that is the constants b, c, etc., are zero. This gives the well-known Rasch equation $\log L = -c_2/\lambda_L\theta + \text{const.}$ Case II. $\lambda_L = a + b/\theta$ which gives Nutting's equation $L = A(B/\theta + 1)^{-C}$, where $B = b/a$ and $C = c_2/b$. Case III. $\lambda_L = a + b/\theta + c/\theta^2$ which gives $L = A(B + \theta)^D(C + \theta)^{-D}$, where—

$$B = [b - \sqrt{(b^2 - 4ac)}]/2a,\ C = [b + \sqrt{(b^2 - 4ac)}]/2a,\ D = c_2/\sqrt{(b^2 - 4ac)}.$$

The actual values of the constants in the equations of the three cases are given in the paper, and it is shown that Case III, and, in general Case II, are sufficiently accurate for representing the luminosity of a black body at various temperatures between 1000° and 7000° abs., whereas the Rasch equation may be 50 % in error at 1000° if the value obtained at 3000° is assumed correct.

The highest luminous efficiency which a black body can possess occurs at a temperature such that $\int_0^\infty VJ\,d\lambda \Big/ \int_0^\infty J\,d\lambda = L/(\theta^4 \times \text{const.}) = \text{maximum}$. By substituting L from the equation of Case III the value $\theta_{\text{max.}} = 6547°$ abs. is obtained. J. W. T. W.

703. *A Misconception of the Criterion for Grey-body Radiation.* **P. D. Foote** and **C. O. Fairchild.** (Washington Acad. Sci., J. 6. pp. 193–197, April 19, 1916.)—Lummer and Pringsheim showed 15 years ago that, if the radiation from carbon, maintained at a constant high temperature, was compared spectrophotometrically with that from a black body at different temperatures, then the logarithm of the ratio of the intensities of the two sources for any given λ plotted against the reciprocal of the absolute temperature of the black body gives a straight line. Moreover, the straight lines for various wave-lengths in the visible spectrum intersect at a common point. They suggested that this was a proof of the greyness of carbon, and that the temperature at the point of intersection was the true temperature of the hot carbon. This statement is repeated in a recent paper by Benedict working under Lummer and Pringsheim's direction.

It is shown in the present paper that the theoretical isochromatics obtained from Wien's distribution law by assuming that the emissivity is an exponential function of λ (so that the radiator dealt with is *not* grey) will have a common point of intersection, and this therefore cannot be taken as a proof of greyness. The true temperature is greater than that of the common point. The authors have verified both these statements by experiments on a radiator designed to give radiations which were not grey. D. O. W.

704. *Radiation Theory.* **M. B. Weinstein.** (Ann. d. Physik, 49. 3. pp. 363–372, March 7, 1916.)—A mathematical paper which reaches Planck's fundamental radiation formulæ by a new statistical derivation. It was at first anticipated that this new method would lead to a new result, but, with certain interpretations, it is found to lead to Planck's well-known formulæ. E. H. B.

705. *Thermodynamics of Water-vapour.* **R. Plank.** (Zeits. Vereines Deutsch. Ing. 60. pp. 187–193, March 4, and pp. 213–217, March 11, 1916.)—This is a mathematical paper, which does not admit of complete abstraction. The ordinary technical equations of state for water-vapour which allow of the calculation of the specific volume in the region of importance in practice (up to 20 atmos. and 500° C.) with an error of a few thousandths, lead to values of the specific heat c_p differing appreciably, especially in the neighbourhood of saturation and at the higher pressures, from the results of Knoblauch, Jakob, and Mollier's direct measurements. The author shows that it is possible to deduce an equation of state which, although less convenient than those referred to, yields accurate specific volumes and also furnishes values for the specific heat in agreement with the experimental numbers.

Since it is difficult to arrive at accurate values of c_p from the equation of state, the inverse method is proposed: Jakob's values for c_p are taken as the starting-point and are expressed by a suitable formula independently of the pressure and of the temperature. From this formula the corresponding equation of state is then derived thermodynamically, this then giving true values for the specific volumes. Jakob treated this problem graphically, and the author has attempted to amplify the graphical solution by a purely analytical one, which is more convenient in many ways. It is found, for example, possible to calculate the magnitude of the cooling on throttling, the results agreeing with the measured values. T. H. P.

SOUND.

706. *The Tonoscope.* **C. E. Seashore.** (Science, 43. pp. 592–596, April 28, 1916. Paper read before the Nat. Music Teachers Assoc., Buffalo, N.Y., Dec., 1915.)—It is possible to make vibrations that produce a tone to the ear produce also a picture to the eye—a picture which reveals details of pitch faithfully and far more finely than the ear can hear, and which may, therefore, be employed for the objective measurement of pitch and as a guide in training to sing and play in pitch. The singer standing before an instrument, called the *tonoscope,* sees in clear pictures every pitch movement of the voice as he is singing; he sees exactly how many vibrations per sec. the vocal organs are producing, and thereby can tell, at the very moment of singing a note, what error is involved, even down to the hundredth of a tone. The player of the violin, flute, or cornet, etc., may treat his instrument in the same way. The student of public speaking can study the inflections of the voice and train for mastery. A full account of the tonoscope is given in pp. 1–66 of the Psychological Review (Princeton, N.J.). It works on the principle of moving pictures, technically known as stroboscopic vision. It converts the sound vibrations into pictures on a screen. This screen, which may be seen through an opening on the front, has nearly 20,000 dots so placed that when acted upon by a sensitive light they arrange themselves in characteristic figures for every pitch within the range of the human voice. Each figure points to a number on the screen which indicates the pitch. The dots are arranged into 110 rows; the first row has 110 dots, the next 111, and so on, one dot more in each row, to the last, which has 219 dots. When the tone is sounded the row which has the dot frequency that corresponds to the vibration frequency of the tone will stand still, while all dots move and tend to blur. The row which stands still, therefore, points to a number on the scale which designates the pitch of the tone. The screen contains a sufficient number of rows of dots to cover exactly one octave. Tones above or below this octave are read on this same screen by multiples. E. H. B.

707. *Human Auditory Sensitiveness for Pure Tones of Specified Pitches.* **J. W. Birnbaum.** (Ann. d. Physik, 49. 2. pp. 201–228, Feb. 22, 1916.)—Describes with many diagrams and photographs an arrangement of telephones and resonators for testing the sharpness of hearing of the human subject for pure tones of specific pitches. E. H. B.

708. *Propagation of Sound from Gun-firing and Great Explosions.* **F. Nölke.** (Phys. Zeits. 17. pp. 31–35, Feb. 1, 1916.)—Discusses the various theories as to the explanation of the zone of silence between the first and second regions of audibility with special reference to the works of von der Borne and of de Quervain. [See Abs. 458 (1916).] E. H. B.

ELECTRICITY AND MAGNETISM.

THEORY, ELECTROSTATICS, AND ATMOSPHERIC ELECTRICITY.

709. *Electron Theory of Metals.* **C. W. Oseen.** (Ann. d. Physik, 49. 1. pp. 71–84, Feb. 4, 1916.)—A critical discussion, mainly mathematical, of the current electron-theory of the emission and absorption of a thin metal plate. The author feels doubtful as to whether the problem attacked by the statistical method is really the same as that subjected to experimental investigation.
E. H. B.

710. *Motion of Ions (and Electrons) in an Electric and Magnetic Field and various Dependent Phenomena.* **A. Righi.** (N. Cimento, 11. pp. 5–47, Jan.–Feb., 1916.)—In this theoretical and mathematical paper the author develops his electronic theory of electromagnetic ponderomotive forces [see Abs. 1102 (1915)]. Formulæ are deduced which represent the motion of an electrified particle—electron or ion—under the action of an electric field and of a magnetic field, both uniform. The particle is at first assumed to be entirely free; later it is supposed to occur among molecules, account being taken of the effects due to the incessant collisions. The general formulæ thus obtained are then employed to furnish explanations of such phenomena as the influence of the magnetic field on the distribution of the current in the case of metals, electrolytes, and gases and the theory of magnetic rays, etc. T. H. P.

711. *Ionisation of the Upper Atmosphere.* **W. F. G. Swann.** (Terrest. Magn. 21. pp. 1–8, March, 1916.)—From various points of view there are indications that the upper atmosphere is to be treated as a region of high electrical conductivity. One of the first theories which took this hypothesis as one of its bases was that developed by Schuster to account for the diurnal variation of the earth's magnetism [see Abs. 1158 (1908)]. There are different sources to which the necessary ionisation may be ascribed, but the most natural is that of the ultra-violet light from the sun. In the present paper some calculations are made to determine the possibility of this cause leading to the required effect. Considering first the fraction of the solar energy that is available for gaseous ionisation (wave-length less than 135 $\mu\mu$), if the radiation from the sun is treated as black-body radiation, this is deduced to be $1{\cdot}61 \times 10^{-6}$ of the total energy entering the atmosphere. It is assumed that the ionisation is confined to a layer 800 km. thick and the number of ions which will be produced per cm.^{3} per sec. by this energy is then calculated. Taking suitable values for the coefficient of recombination and the specific velocities of the ions in the high altitudes considered, the specific conductivity σ is next deduced to have a value of 8×10^4 e.s. units. The value of σ required by Schuster is about 10^8 times as large as this. The above calculation is based on the assumption that the atmospheric pressure in the layer is 1 dyne per cm.^{2}, and the assumption of a smaller pressure provides a loophole out of the difficulty. A curious result which arises from a further calculation on these lines is that the conductivity of the atmosphere should theoretically tend to an infinite value with increase of altitude, if we assume the laws of variation of the various quantities with pressure which hold at pressures that are measurable to apply also with smaller pressures. The physical reason for this lies in the increase in the specific velocity of the ions with diminution of pressure, that is, with increase of altitude. J. S. Di.

DISCHARGE AND OSCILLATIONS.

712. *Ionic Mobilities in Hydrogen.* II. **W. B. Haines.** (Phil. Mag. 31. pp. 339–347, April, 1916.)—In a previous paper [Abs. 1729 (1915)] the preliminary results were given of experiments showing the presence of several kinds of negative carriers in pure hydrogen ionised by α-rays. Experiments have now been made at different pressures, so that a revised and extended series of measurements can be given. Measurements were made of the mobilities of the positive ion and three different negative ions in hydrogen over a range of pressures between 8 cm. and 76 cm. The results for two of the negative ions are expressed by the equations $\mathrm{P}u = 604{\cdot}7$ and $\mathrm{P}u = 1206$ respectively. The work for the third and lightest ion is not yet so complete. Theoretical considerations indicate that the three negative ions are built up from elements containing respectively 1, 3, and 6 molecules of hydrogen per electronic charge, and the element in the positive ion has 9 molecules per electronic charge. A. W.

713. *Direct Photoelectric Determination of Planck's "h."* **R. A. Millikan.** (Phys. Rev. 7. pp. 355–388, March, 1916.)—In 1905 Einstein, connecting photoelectric effects and quantum theory, proposed the following equation for the max. energy of emission of corpuscles under the influence of light: $\frac{1}{2}mv^2 = \mathrm{V}e = h\nu - p$, in which $h\nu$ is the energy absorbed by the electron from the light wave, p the work necessary to release the electron from the metal surface, and $\frac{1}{2}mv^2$ the energy with which it leaves the surface—an energy measured by the product of its charge e and the p.d. against which it is just able to drive itself before being brought to rest. The results of the present series of observations seem to show that at least five of the experimentally verifiable relationships which are actually contained in the above equation are rigorously correct. These relationships are embodied in the following assertions: (1) That there exists for each exciting frequency ν, above a certain critical value, a definitely determinable max. velocity of emission of corpuscles; (2) that there is a linear relation between V and ν; (3) that $d\mathrm{V}/d\nu$, or the slope of the $\mathrm{V}\nu$ line, is numerically equal to h/e; (4) that at the critical frequency ν_0 at which $v = 0$, $p = h\nu_0$, *i.e.* that the intercept of the $\mathrm{V}\nu$ line on the ν axis is the lowest frequency at which the metal in question can be photoelectrically active; (5) that the contact e.m.f. between any two conductors is given by the equation: contact e.m.f $= h/e(\nu_0 - \nu_0') - (\mathrm{V}_0 - \mathrm{V}_0)$.

The author reviews previous work on the above points, in particular the work of Elster and Geitel, Richardson and Compton, J. J. Thomson [Abs. 586 (1915)], Hughes [Abs. 1874 (1912)], and by Hennings, Wright and Kadesch (in the author's laboratory).

The present work is much more exhaustive in character than that of previous workers, each of the above 5 points being very carefully tested by experiment. A detailed description is given of the methods employed in removing surface films *in vacuo*, measuring photo-currents and photo-potentials, and the simultaneous measurement of the contact e.m.f.'s of the surfaces. Sources of error and their elimination are points next considered. A series of extremely careful experiments are then described, in which the value of Planck's constant "*h*" is photoelectrically determined with an accuracy of about 0·5 %.

The value found is $h = 6{\cdot}57 \times 10^{-27}$, which the author considers is by far the most reliable value of "*h*" that is thus far available.

Contact e.m.f. and the long-wavelength limits of photo-sensitiveness are examined carefully, the paper concluding with a discussion of various theories of photo-emission.

Einstein's photoelectric equation, after being subjected to very searching tests, appears to predict exactly the observed results. A. B. W.

714. *Repulsion Effect in the Electric Arc.* **A. Sellerio.** (N. Cimento, 11. pp. 67–86, Jan.–Feb., 1916.)—The reaction upon a point from which an electric discharge is taking place has been studied by S. Arrhenius and E. J. Moore [Abs. 910 (1912)] and the author has applied a similar method to the carbons of the electric arc. One carbon is carried at the extremity of the arm of a torsion balance so that the force upon it, in the direction of a repulsion from the other carbon, can be measured in terms of the twist in a fine wire, and on suitable calibration converted into dynes. The current, voltage, length of arc, and area of crater are also measured. The chief results are as follows:—The force on the positive carbon is greater than that on the negative carbon; the repulsion increases with the current and diminishes slightly as the length of arc is increased; the order of magnitude of the force for currents up to 20 amps. is in milligrammes weight. Various carbons, solid and cored, equal and unequal are used and curves are given connecting torsion and current. These consist of broken lines, the sections being straight and meeting at angles approaching 180°. The force goes through several stages as the current increases, and passes with discontinuity from stage to stage. Impregnations of metallic salts increase the force on the negative carbon and decrease that on the positive. S. G. S.

715. *Arc and Glow Discharge.* **M. La Rosa.** (N. Cimento, 11. pp. 48–66, Jan.–Feb., 1916.)—Further experiments [see Abs. 1362 (1912)], with the aid of photographs of the discharges, show that arc and glow discharge represent the extreme, most stable forms of a whole series of intermediate forms which exhibit, more or less highly developed, the elements characteristic of each type of discharge. This varying degree of development depends principally on the properties of the substance of the electrodes. Thus, with carbon, owing to its feeble thermal conductivity and perhaps also to the marked Edison-effect that it possesses, the craters should be especially persistent, either when the carbon functions as kathode or when it acts as anode towards a kathode but little adapted to the formation of craters. In the last case, a true crater persists on the carbon rod even when the discharge on the other electrode, for instance, an Al plate, is distinctly of the glow discharge type. Such obstinate persistence of the craters, due to the properties of the electrodes and not to intrinsic modality of the type of discharge, would, when the discharge passes between two carbons, probably mask all the intermediate forms which the discharge could assume.

With silver, for opposite reasons, the contrary occurs; the craters have but slight stability and the more persistent form is the glow discharge. Hence, a silver kathode and a carbon anode give readily a discharge of mixed type and with difficulty an arc; with the silver as anode, the reverse is the case. Aluminium has intermediate properties highly favourable to the gradual development of the various forms taken by the discharge. Its conductivity, which is neither too high nor too low, permits of the formation of craters (positive and negative), which are, however, not so stable as with carbon; further, the alteration of its surface favours the transformation of the discharge, since it regulates automatically and very gradually the intensity of the current. Another property of Al which probably contributes considerably to the phenomenon is its ready emission of an abundant stream of negative electrons under the action of various causes; such a property should render aluminium especially suitable to function as a kathode in the glow discharge. Photographs of the various types of discharge are reproduced. T. H. P.

ELECTRICAL PROPERTIES AND INSTRUMENTS.

716. *Force exerted between Coaxial Circular Current-carrying Conductors.* **F. W. Grover.** (Bureau of Standards, Bull. 12. pp. 817–878, Feb., 1916.)—This paper comprises a complete statement of previous formulæ and includes the development of a more direct solution of the case where two parallel, coaxial, circular coils are placed at such a distance that their mutual attraction or repulsion is a maximum. Methods for the application of the formulæ, worked-out examples, and tables to facilitate calculation are given. The paper does not permit of a more detailed abstract. W. H. G.

717. *Light-sensitiveness of Copper Oxide.* **A. H. Pfund.** (Phys. Rev. 7. pp. 289–301, March, 1916.)—A more complete account of the work dealt with in Abs. 234 (1916).

718. *The Hypotheses of Faraday and Mossotti and Certain Conditions satisfied at the Contact of Two Dielectrics.* **P. Duhem.** (Comptes Rendus, 162. pp. 409–418, March 20, 1916.)—A mathematical paper. I. W.

ALTERNATING CURRENTS AND MAGNETISM.

719. *Reversible Change of Residual Magnetisation with Temperature.* **G. J. Elias.** (K. Akad. Amsterdam, Proc. 18. 7. pp. 1068–1071, 1916.)—When the temperature of a ferromagnetic body that possesses residual magnetism rises, the magnetism changes too (decreases, say). If then the magnet is again cooled to its original temperature, the magnetisation increases again, but not to its original value. If this heating and cooling is repeated a state is finally reached in which the changes are reversible; that is to say, by a rise of temperature the magnetisation decreases as much as it increases again by the following equal fall of the temperature. This reversibility only holds between the limits of temperature used here. A quantitative study of the phenomena was then carried out experimentally, and the results of G. R. Ashworth for steel (1898) were confirmed. E. H. B.

720. *Change of Length of Nickel Wires of Different Rigidities due to Alternating Magnetic Fields.* **W. Brown.** (Roy. Dublin Soc., Proc. 15. pp. 41–50, Feb., 1916.)—The results of further experiments on Ni wires when subjected to the influence of alternating magnetic fields of frequencies up to 150 per sec. are given. The wires used were in five different states of rigidity, and the fields employed were longitudinal and both direct and alternating. The method used was the same as in the previous experiments, the rigidity being measured by a modification of Searle's torsion apparatus. Some difficulty

was found due to changes of length arising from the heating effect of the field on the wire. As the load on the wire was increased, in general the contraction decreased. When in the case of a wire of rigidity 810 × 10^6 gm./cm.^{2} the load was increased 16 times the contraction decreased about 10% for the longitudinal magnetic field, and about 80% for an alternating magnetic field of frequency 150 per sec. When the rigidity of the wire used was 708 × 10^6 gm./cm.^{2} the decrease of the contraction was half as much again in the soft state as when the wire was harder. Details are given in tables of the values of the contraction in different cases as affected by the rigidity load and magnetic field. An interesting result is obtained when a comparison is made of the values of the rigidity and the values of the contraction obtained with longitudinal magnetic fields of 200 units produced by direct current and alternating current of frequency 150 per sec. when the wires are under the influence of two different loads. If the values of the rigidity are taken as abscissæ and the corresponding values of the contraction as ordinates the points on the curve obtained both in the case of direct and alternating fields lie very approximately on two straight converging lines. Comparing the cases of the wires of highest and lowest rigidity used (810 and 708 × 10^6 gm./cm.^{2}) it is seen that when the load on the wires is 0·5 × 10^6 gm./cm.^{2} a decrease of the rigidity of about 12·5% is accompanied by an increase of contraction of about 60% for a direct field and of about 80% for an alternating field of frequency 150 per sec., the magnitude of the field being 200 c.g.s. units. J. J. S.

721. *Statistical Theory of Dia-, Para- and Meta-magnetism.* **R. Gans.** (Ann. d. Physik, 49. 2. pp. 149–178, Feb. 22, 1916.)—Metamagnetic bodies are those recently observed by Weber and Overbeck [Abs. 1885 (1915)], which are paramagnetic in weak fields and diamagnetic in strong fields. A mathematical theory is developed which includes this new class of body. Assuming that a magneton consists of a rigid system of electrons, it follows that the behaviour is always diamagnetic if the magneton possesses no axis of figure. If the three principal moments of inertia are all equal, the diamagnetic susceptibility is independent of the field and temperature. This has often been observed. If the principal moments of inertia are not all equal, there is an effect due to field and temperature, as Honda has shown to be the case, except for very low temperatures. A quantitative comparison of the theory with measurements should give the number of magnetons in the gramme molecule, and also the principal moments of inertia of the molecule. If the magneton has an axis of figure, the behaviour is paramagnetic. The magnetic moment then remains constant with time; it is also independent of temperature, as Weiss found, and has also a finite value at absolute zero. On account of this fact it is not therefore necessary to assume an energy value for absolute zero temperature. Further, whilst diamagnetism may appear alone, this is not the case with the paramagnetic state with which diamagnetism is always associated in the form of thermal rotations round the equatorial axis. In weak fields and at low temperatures, the paramagnetic condition will preponderate, but with increase of field and rise of temperature this may change to the diamagnetic state, as was shown by Weber and Overbeck. [See Abs. 1449 (1905), 1128 (1915) and *loc. cit.*]

G. E. A.

722. *Magnetic Laws for Steel and other Materials.* **J. D. Ball.** (Franklin Inst., J. 181. pp. 459–504, April, 1916. Gen. El. Rev. 19. pp. 369–390, May, 1916.)—The paper begins with the consideration of the reluctivity law of

Kennelly and the hysteresis law of Steinmetz. From an examination of many reluctivity-field graphs, the graph is found to consist chiefly of two straight lines, which are nearly in line, the bend occurring at a definite value of the field, *e.g.* $B=80$ for a high-silicon steel. Tests on a commercial Si steel show that the Steinmetz law is followed as far as $B=10{,}000$, but that with greater flux density there is an apparent divergence, the loss being greater than is demanded by theory. The causes of the apparent deviations from these magnetic laws are next considered. The bend of the reluctivity curve indicates that the component parts of the material under test may be divided into two magnetic constituents. The softer constituent carries a greater proportion of the flux until approaching saturation reduces its permeability, after which the additional flux is forced into the harder material whose permeability is correspondingly increased. This view is strengthened by the fact that a pure metal gives a straight reluctivity cure within the limits of the test. The deviation from the theoretical hysteresis curve also indicates that a heterogeneous material is under test. The most prominent deviations from the two laws do not, however, occur at the same value of H. Sheet Si steel, as commercially used, is taken as an example of non-homogeneous material, being iron with about 10 % scale. The magnetic properties of the scale from Si steel were first determined, and the index 1·6 of the Steinmetz law is found to hold only for the highest inductions; this index gives a value 0·0216 for η, the Steinmetz constant. The reluctivity graph gave practically a straight line from $H=40$ to $H=105$, and another straight line from $H=105$ upwards. The max. permeability of the steel scale was 154 at $B=8700$, and saturation B was about 8700. Taking these values in conjunction with the corresponding values for Si steel, the total flux for a series of fields is calculated for a specimen assumed to be made up of 90 % steel and 10 % scale. The hysteresis losses are then calculated for the two parts of the composite body by means of the Steinmetz law. When log (hysteresis) is plotted against log B, the graph is a straight line to about $B=12{,}000$, beyond which the increase in hysteresis is greater than if the 1·6 law held for the mixture. This agrees with experiment, and might easily account for the apparent increase of hysteresis in sheet steel at high inductions. Further experiments were made with iron and cobalt in nearly pure condition. These were tested in ring shape, first separately and then together, small flat rings of the two metals being employed. Whilst the reluctivity curve for Co is straight, that for iron bends slightly at about $H=84$, and that for the composite ring has a sharp bend for $H=55$. Hysteresis measurements for the rings give a line having a slope of 1·62 to $B=6000$, beyond which there is an abnormal increase of hysteresis. In an investigation of asymmetrical loops it is stated that the hysteresis loss per cycle can be expressed by the equation: $h=(\eta+a B_m^{1\cdot 9})B^{1\cdot 6}$, where a is a coefficient depending on the material, and B_m is the mean induction for the loop. In an appendix, some additional properties of steel scale are described, such properties as high frequency, skin effect, and eddy-current losses. According to a calculation, the max. allowable thickness of scale which has no appreciable skin effect at 10,000 cycles is 0·015 in., and the max. frequency to give no skin effect is 480,000 cycles per sec. G. E. A.

723. *Electrical and Magnetic Properties of Pure Iron in Relation to Crystal Size.* **F. C. Thompson.** (Phil. Mag. 31. pp. 357–366, April, 1916.)—The author has previously studied the effect of crystal size on the elastic strength of metals [Abs. 278 (1916)]. At the crystal junctions was supposed a layer of the metal in an amorphous state. The estimated thickness of this layer was 10^{-8} cm. In the present paper electrical resistance and magnetic properties are dealt with from the same point of view. Pure Swedish bar iron was chosen since the crystal size can be varied over a wide range by suitable thermal treatment. Four specimens were prepared in which the number of crystals varied from 276 to 690 per cm. length. Whatever the number, the length of crystalline metal traversed by the current is sensibly the same. The observed specific resistance ρ_1 can thus be written $\rho_1 = \rho_2 + n\mathrm{R}$ where ρ_2 is the specific resistance of the crystalline portion, n the number of crystals per cm. length, and R the boundary resistance for each grain. For the specimens examined the author deduces $\rho_2 = 6{\cdot}83$ and $\mathrm{R} = 1{\cdot}72 \times 10^{-3}$ microhms-cm. A fifth specimen subjected to prolonged annealing showed a very irregular structure consisting of coarse and fine grains. The specific resistance was 7·152 microhms-cm. For the other specimens ρ_1 varies from 7·251 to 7·986. The difference in crystal size probably accounts for the different values of the specific resistance obtained by different observers. In the case of a metal like copper little variation of crystal size can be obtained, consequently determinations of specific resistance agree with one another. Alloys which consist of a single solid solution should conform to a law similar to that above. A Cu-Zn-Ni alloy was examined, but the diminution in specific resistance on coarsening the structure by annealing was very small. The author supposes internal strains set up rendering the conductivities of the crystalline and amorphous parts probably the same. Benedicks has measured the specific resistance of steels and has represented his results by $\rho = 7{\cdot}6 + 26{\cdot}8\,\Sigma c$, where Σc is the sum of the carbon and the equivalents in carbon of the other elements present in solution. This can only be regarded as an approximation to the truth since it takes no account of grain size. v. Weimarn, by analogy with the resistance of colloidal solutions, has proposed a formula similar to the author's. For a binary alloy Rayleigh expresses the added resistance by $278e^2/[k/p + k'/q]$, where e is the thermoelectric power of the components of the alloy, k and k' are their thermal conductivities and p and q the practical volume of each. In a pure metal if k and p correspond to the crystal portion and k' and q to the amorphous part the expression reduces to $278e^2q/k'$ and q is proportional to n. Thus the total resistance will be an expression of the same form as that proposed by the author.

For a max. magnetising field of ·95 c.g.s. the induction was practically the same for all specimens, viz. 18,400. The remanent magnetism was uninfluenced by size of crystal. The constancy of permeability is contrary to what we should expect at first sight. The increase of permeability of iron by alloying with Al, Si, or P has usually been ascribed to the production of larger crystals. The author considers, however, that the removal of oxygen by these added constituents is the more possible cause of increased permeability. The coercive force and the hysteresis loss per cycle (e) increase with the number of crystals per unit length. The author also determined the Brinell hardness (H) for the different specimens and finds $e = 30\mathrm{H}^{1{\cdot}8}$. The specific resistance of the "drastically" annealed sample was relatively low, the larger grains being the determining factor, but as regards magnetic hardness the smaller grains are predominant as the specimen has a relatively high coercive force. L. L.

724. ***Significance of the Dependence between Magnetic Susceptibility and Dissociation. Association between Ions and Solvent.*** **A. Quartaroli.** (Soc.

Chim. Ital., Gazzetta, 45. 1. pp. 158–160, 1915.)—It has been observed that the atomic susceptibility of Fe and of Mn, in solutions of their salts, increases with the dilution, and the author found a similar increase with solutions of ferric chloride to which hydrochloric acid had been added in order to prevent hydrolysis [see Abs. 922 (1915)]. There appears, indeed, to be a well-defined relation between magnetic susceptibility and electrolytic dissociation. The action of a magnetic field on a magnetic disperse system is discussed for the cases in which the disperse phase consists of: (1) macroscopic granules, (2) microscopic and ultramicroscopic granules, (3) amicrons and non-dissociated molecules, and (4) ions. If the solution is placed between the poles of a powerful electromagnet, then, in case (1) the granules will be attracted, and will move through the liquid towards the poles; when a little potassium sulphate is added to a moderately dilute ferric chloride solution, the granules of ferric hydroxide formed will not at first be attracted, but when they have increased sufficiently in size, a slight attraction will be observable. In colloidal solutions of magnetic substances no measurable variation occurs in the different parts of the liquid, and this behaviour is explained, on the basis of Stokes' law, as a result of the smallness of the particles. The same reasoning applies with greater force in the case of amicrons and undissociated molecules. With ions, also, no variation in the concentration takes place under the influence of the field, but the whole of the liquid undergoes either attraction to the poles or, with dilute solutions, less repulsion than is exerted on the solvent alone. In this case, then, the ions behave as though rigidly connected with the solvent, and in view of the relation between susceptibility and dissociation the conclusion is drawn that the ions and the water are bound together by electrostatic attraction. These results are discussed in their relation to Ciamician's hypothesis concerning the state of solutions of electrolytes. T. H. P.

725. *On the Hall-effect and Allied Phenomena.* **A. W. Smith.** (Phil. Mag. 31. pp. 367–368, April, 1916.)—Critical note with reference to Livens' statements [see Abs. 1549 (1915)]. Smith points out that the Hall-effect and the permeability depend in different ways upon the temperature; consequently the variation of the Hall-effect with the temperature cannot be entirely accounted for by the variation of the permeability with the temperature. L. H. W.

RADIOGRAPHY AND ELECTROPHYSIOLOGY.

726. *The Bases of Dosimetry in Radiology.* **R. Ledoux-Lebard** and **A. Dauvillier.** (Comptes Rendus, 162. pp. 405–407, March 13, 1916.)—The determination of the dose of Röntgen rays used in radio-therapy is a very complex question. The different methods which, up to the present have been employed all present marked selective effects, and consequently require, first of all, qualitative measurement. They give only a mean value; some of them are inconvenient, and not one of them enables a precise measurement of the intensity or quality of the radiation to be made, because the latter is always very heterogeneous. If it is desired to introduce into radio-therapy rational and incontestable means of determining the dose, it becomes necessary first of all to modify the sources of the rays by making tubes which give a monochromatic radiation the quality and intensity of which can be immediately measured with exactitude. It is further necessary to modify the sources of high-tension current such as are at present used. It is proposed

to employ a continuous current for tubes used in radio-therapy, particularly in the case of those fitted with a Coolidge kathode. A Coolidge tube run with a continuous current supplied from a condenser charged by a coil or a turning contact gives a bundle of rays absolutely continuous: the phenomenon of discontinuity of kathodic emission does not exist in such a tube. Further, the fact that the intensity is independent of the voltage makes it possible for the tube to be mounted directly on the terminals of the condenser. Ordinary and Coolidge tubes, run with continuous current, show no difference in the power of penetration of the rays from those obtained directly by means of a coil. The rays have a hardness of 8·5° Benoit with an equivalent spark of 16 cm., which corresponds to a static potential of 80,000 volts. After some difficulty, condensers have been made which support easily a pressure of 100,000 volts per element, and by joining them up in cascade it is possible to make them good for 200,000 volts. Under these conditions the apparatus gives exact indications which are easy to interpret, and it is possible always to obtain identical conditions. A. E. G.

727. *Illusory Protection against Röntgen Rays—Physical Anaphylaxis.* **J. Bergonié.** (Archives d'Él. Médicale, 24. pp. 111–112, April, 1916. Comptes Rendus, 162. pp. 613–614, April 17, 1916.)—It appears that tissue that has once been effected by Röntgen rays remains for a long time more or less sensitive in respect to those rays. It has been found that while in the case of a normal skin in order to provoke a sensible reaction it takes a dose which corresponds to a 15-minute exposure at a distance of 20 cm. of the kathode of a Chabaud-Villard tube emitting rays of 6° Benoit and run by a current of 0·5 milliamp., in the case of a sensitive subject an exposure measured in seconds is sufficient, and the distance is measured in metres. In fact, in a hypersensitive subject a dose of 1/1600 of that normally required will produce a noticeable reaction. This reaction which follows such extremely small doses cannot be attributed to suggestion. Certain well-marked changes in the tissues, and other effects, are described. A. E. G.

728. *Modified Technique of Localisation by means of Hirtz's Compass.* **J. de Poliakoff.** (Archives d'Él. Medicale, 24. pp. 97–109, April, 1916.)—[For description of Hirtz's arrangement see Abs. 768, 928 (1915).]

729. *The Injurious Effects produced by X-rays.* (Röntgen Soc., J. 12. pp. 38–56, April, 1916. Discussion.)—A good deal of practical information is given by the contributors to the discussion; for this the original pages should be consulted. L. H. W.

CHEMICAL PHYSICS AND ELECTRO-CHEMISTRY.

730. *Action of Kathode Rays on Bismuth.* **W. P. Jorissen** and **J. A. Vollgraff.** (Chem. Weekblad, 12. pp. 741–744, 1915.)—When examined spectroscopically, bismuth is found to contain traces of thallium. It is now claimed that the amount of Tl appears to be increased by subjecting the Bi to exposure to kathode rays. L. H. W.

731. *Preparation of Metallic Vanadium.* **R. Edson** and **D. McIntosh.** (Roy. Soc. Canada, Trans. 9. pp. 81–83, 1915.)—The method described, whilst inapplicable for the preparation of vanadium on a large scale, may be used with advantage in the laboratory, or for demonstration in the lecture-room.

A flask, containing some vanadyl chloride, is fitted with a Pt-wire filament, attached to two heavy copper leads, and also with inlet and exit tubes for the passage of a current of dry hydrogen. The filament is made to glow by passing a current through it, and the V is deposited smoothly on the Pt as a silvery-grey coating. The experiment may be carried out either in a vacuum or in an atmosphere of hydrogen at low pressure. As soon as the filament reaches a white heat the deposition begins, and can be continued until the wire burns out.

The vanadyl chloride is made by heating a mixture of the pentoxide and charcoal in a stream of chlorine, and need not be purified from any vanadium tetrachloride it contains. T. S. P.

732. *Gallium-Indium Alloy.* **P. E. Browning** and **H. S. Uhler.** (Am. J. Sci. 41. pp. 351–354, April, 1916.)—Mercury-like globules on the surface of a leady residue from the distillation of zinc kept in a warm place, proved to be a gallium-indium alloy containing about 10 % of indium. The boiling-point of pure gallium *in vacuo* is above 1600° and its density 5·91 gm. per cm.^{3} at 20°. The spectroscopic properties of gallium are under investigation.

T. H. P.

733. *Compounds of Selenium with Silver.* **G. Pellini.** (Soc. Chim. Ital., Gazzetta, 45. 1. pp. 533–539, 1915.)—The melting-point diagram of the system Ag Se rises rapidly from the melting-point of Se (217°) to 616°, and then remains horizontal between 4–5 and 52 atom. % of silver, beyond which it again rises rapidly to a maximum of 897°, corresponding with 66·6 atom. % Ag. Next a sharp fall takes place to 845° (67–68 atom. % Ag), this being followed by a rise to 890°, at which point the temperature remains from 68 to 89 atom. % Ag. Finally a rise occurs to the melting-point of silver. The melting-point found for the compound Ag_2Se, 897°, is higher than the values given by Pélabon [Abs. 1221 (1908)] and Friedrich and Leroux, namely 880° and 850° respectively. Like the analogous compounds, Ag_2S, m. p. 842° [Jaeger and Klooster, 1912], and Ag_2Te, m. p. 959° [Pellini and Quercigh, Abs. 164 (1911)], Ag_2Se melts without decomposition. No compound analogous to AgTe is formed in the case of Se. The three compounds, Ag_2S, Ag_2Se, and Ag_2Te are polymorphous-enantiotropic, the transformation-points being at 90° and 179°, 122° and 133° respectively. Silver selenide exhibits miscibility gaps in the liquid state with Ag and Se, just as is found with the system Sb-S (Jaeger and Klooster) and, possibly, Sn-Se (Guertler, "Metallo-

graphie," I. 966). The tellurides of silver present no miscibility gaps with their respective components, but silver shows such a gap with Ag_2S, study of mixtures richer in sulphur not being possible. T. H. P.

784. *Alloys of Manganese and Bismuth.* **N. Parravano and U. Perret.** (Soc. Chim. Ital., Gazzetta, 45. 1. pp. 390–394, 1915.)—Wedekind and Weit and Hilpert and Dieckmann [Abs. 210, 211 (1912)] have prepared the crystalline compound, MnBi, and Bekier [Int. Zeits. f. Metallographie, 7. p. 83, 1914] has investigated the diagram of state of Mn-Bi alloys. The results of the authors' examination of this diagram are essentially identical with those obtained by Bekier, and show that the two metals are partly miscible in the liquid condition, and form a compound which originates by peritectic reaction at about 450°. With reference to the concentrations of the two liquid strata in equilibrium at a high temperature and also as regards the composition of the compound, the authors' data differ from Bekier's figures. The invariant temperature is found to be 1238°, and the proportions of Mn in the two equilibrated mixtures are 80 % and 98 % respectively. Study of the cooling curves for mixtures of various compositions shows that the maximal thermal effect occurs with an alloy containing 20 % of Mn, which corresponds well with the compound MnBi. Crystals were also separated which gave, on analysis, 20·42 % of Mn and 80·1 % of Bi. T. H. P.

785. *Preparation of Pure Iron and Iron-Carbon Alloys.* **J. R. Cain, E. Schramm, and H. E. Cleaves.** (Bureau of Standards, Bull. 13. pp. 1–25, 1916. [Sci. Papers, No. 266].)—The investigations carried out up to the present time on the equilibrium diagram of the iron-carbon system cannot be regarded as exhaustive, because in no case have the investigators worked with pure materials. On this account the authors have prepared a series of alloys containing 0·08 to 3·27 % of carbon to serve as the basis for an accurate study of the thermal equilibrium of the Fe-C system. Pure iron has been made by the electrolysis of American ingot iron, and a detailed study has been made of the fusion of the product. Sources of contamination have been studied and the methods of elimination of the impurities have been worked out. Finally the iron was melted down in pure magnesia crucibles. Pure sugar-carbon was used for making the alloys, and in no case did the total content of impurities (Si, S, P, Mn, Cu, Co, and Ni) exceed 0·05 %. A method has been devised for casting sound ingots without the use of deoxidisers. The methods of analysis used are described and the results were confirmed by spectroscopic examination. F. C. A. H. L.

786. *Compounds of Iron, Manganese, Lead and the Metals of Group II.* **S. U. Pickering.** (Chem. Soc., Trans. 109. pp. 235–250, March, 1916.)—Having previously shown that cobalt and nickel form metallo-compounds similar to those of copper, the author has extended his work to the study of the compounds of other metals with organic acids. When first formed, a metallo-compound appears to contain the elements of water in addition to the formula MR, but in many cases it can be dehydrated without losing its distinctive properties. In this condition it is strictly isomeric with the normal salt, from which, however, it differs markedly in physical properties, and also in constitution, for electrolysis shows it to contain the metal in the anion. Organic salts of metals exist in two forms—the normal salt, which is a sparingly soluble crystalline compound, and the metallo-salt which is much more soluble and is generally obtained in the form of an emulsion. It changes spontaneously into the normal salt. Over 40 pairs of such compounds have been obtained, and in them 18 metals and 5 organic acids figure. The metal in them exists in the quadrivalent form, and while it is not surprising that Fe, Pb, Mn, Co, and Ni can act as tetrads, the cases of the metals of the calcium and zinc groups are somewhat different. It is clear that ideas respecting valency must be enlarged in view of such knowledge as the fact of Pt being hexavalent in the compound K_2PtCl_6. In the majority of elements, with the possible exception of carbon and hydrogen, there appear to be residual affinities, and although a residual affinity may not be powerful enough to attach itself to a third atom, it may satisfy itself at the expense of another residual affinity. F. C. A. H. L.

737. *Electrical Resistance of Acetic Acid in the Solid and Liquid Phases.* **J. H. L. Johnstone.** (Nova Scotian Inst. of Sci., Proc. and Trans. 13. pp. 191–208, April 8, 1915.)—Three methods have been investigated for the measurement of high electrolytic resistances and found to yield satisfactory results. Measurements of the specific resistance of acetic acid in the solid and liquid phases over the temperature range —80° C. to + 27° C. show that sudden changes occur at the melting and eutectic points. It is found that the resistance in the solid phase above the eutectic point varies in a peculiar manner, and investigation shows that this behaviour is due almost entirely to the effect on the resistance of the small proportions of water present in the acid. For the liquid phase, the temperature coefficient is nearly constant and equal to 0·04, whereas for the solid phase it varies from 0·30 at —48° C. to 0·25 at —70° C. T. H. P.

738. *Magneto-chemistry: Applications to Analytical Chemistry.* **A. Quartaroli.** (Soc. Chim. Ital., Gazzetta, 45. ii. pp. 406–423, 1915.)—Even in moderately concentrated solutions, ordinary salts, such as those of the alkali and alkaline-earth metals, aluminium, ammonium, etc., which are diamagnetic, exhibit in general susceptibilities differing little from that of water. Further, the difference in susceptibility between concentrated solutions of magnetic salts and water is some hundreds of times as great as that between concentrated solutions of diamagnetic salts and water. In order to be able to utilise magneto-chemical data in quantitative analysis, the author employs a method based on the fact that water is diamagnetic, and that there exists for each magnetic salt a concentration at which its aqueous solution is magnetically inactive. For the measurement of these concentrations the use of Quincke's manometer is tedious and the author employs an apparatus based on the fact that a current of air-bubbles escaping from a capillary tube dipping below the surface of a magnetic solution situate between the poles of an electromagnet is retarded when the magnet is excited; on the other hand, no retardation or acceleration occurs with a liquid which is inactive or, more accurately, has a susceptibility equal to that of air. The apparatus, which is readily fitted up, is depicted and the method of using it described. The accuracy attainable is shown by the fact that a distinction is readily made between manganous chloride solutions containing 2·59 gm. (inactive) and 2·57 gm. of Mn per litre; still greater accuracy would result from the use of a magnetic field of more than 25,000 gauss, which was about the value employed by the author.

These critical concentrations have been determined for a number of ferric, ferrous, manganous, cobalt, nickel, and copper salts. The influence of the anion is negligible, excepting in the case of the sulphates, and, unless they are present in very large excess, the ordinary diamagnetic salts or mineral acids produce only small alterations in the inactive concentration of the magnetic salt.

In determining the concentration of a salt of a magnetic metal in solution, the latter is either diluted with water or concentrated by evaporation or addition of a stronger solution of the salt, until it becomes magnetically inactive. From the known degree of the dilution or concentration necessary, the initial concentration may be calculated. Where other metals are also present, the method may often be used in conjunction with ordinary analytical methods. Its use in this way is described for the estimation of: (1) Cr, Fe, or Mn in presence of Al; (2) Fe and Cr together; (3) Fe, Mn, Al, and P; (4) Cr and Mn; (5) Ni and Co. T. H. P.

739. *Preparation and Properties of Colloidal Carbon.* **P. C. L. Thorne.** (Chem. Soc., Trans. 109. pp. 202–209, March, 1916.)—Having given a brief review of the literature on the subject, the author describes his experiments. Finely powdered sucrose is introduced, under shaking, through a funnel with a narrow neck into concentrated sulphuric acid, in which it dissolves; after standing 24 hours the liquid is poured into 4 times its volume of distilled water and then filtered. The yellow or brownish filtrate parts with most of its acid in a dialyser of parchment paper; finally the coloured liquid passes through the membrane. The solution does not show many particles in the ultramicroscope; in an electric field the particles travel to the anode; addition of an electrolyte (barium nitrate) produces cloudiness and a brown powder settles. The strong acid thus seems to produce some carbon in the suspensoid state, and a much greater amount of complex organic compounds. Dilute caustic soda was then decomposed with carbon electrodes (arc carbons, Acheson graphite) by currents of 0·4 to 4 amps. at 200 volts; one electrode was immersed, the other just touched the surface of the solution. The electrodes are disintegrated and a dark solution is produced, most of the particles passing through the filter and requiring months to settle. Dispersion occurs best when the positive pole touches the surface; when this pole is negative, an arc is formed and carbon burns away; an arc struck in the liquid gave only a few, but large, particles. The sol originated chiefly from the positive pole; a solution containing 2 or 3 gm. of NaOH per litre is most suitable. The sols thus obtained lose their alkali on dialysis, and are precipitated if entirely deprived of alkali (just as ferric hydroxide is precipitated when all its acid is removed). The sol shows a Tyndall cone and looks black in layers of a few mm.; in the ultramicroscope many particles in Brownian movement are seen. The sol is very sensitive to the presence of electrolytes, and the particles are as rapidly precipitated as they are formed when tap water is used. As regards the amount of electrolyte required for coagulation they behave like arsenic trisulphide. Burnt in oxygen the sol seemed to contain 66 % of C, 2 of H, 15 of an insoluble residue (SiO_2 from the carbon electrodes), the rest (16 %) being probably oxygen. It is concluded that to form a stable suspensoid the carbon must be in a state easily to be disintegrated; organic matter should be present (tannic acid in the case of Acheson's unctuous graphite) or be formed during the preparation; alkali aids the suspension, and some trace of an electrolyte seems to be necessary to ensure stability of the sol.

H. B.

740. *A Theory of Multiple Ionisation: a Modification of the Theory of Electrolytic Dissociation.* I. **F. F. Heyroth.** (Am. Chem. Soc., J. 38. pp. 57–65,

Jan., 1916.)—Five points are brought forward in which the ionic theory in its present form fails to give entirely satisfactory explanations of the observed facts, or in regard to which there may be theoretical objections. To meet these points it is suggested that ionisation may take place in more ways than one, and that the strengths of acids and bases depend upon the relative number of molecules ionised as acid and as base. T. M. L.

741. *On Ewell's Method of measuring Single Potential-differences.* **S. J. Barnett.** (Phys. Rev. 7. pp. 331–338, March, 1916.)—A theoretical discussion is given of Ewell's method of measuring single p.d.'s [Abs. 1789 (1915)]. The author shows that certain assumptions made by Ewell cannot be taken as valid, so that the method does not give with any certainty the single p.d.'s it was desired to measure. T. S. P.

742. *Electromotive Forces.* **W. D. Bancroft.** (Am. Electrochem. Soc., Trans. 28. pp. 357–367; Disc., 367–370, 1915. J. Phys. Chem. 20. pp. 64–74, Jan., 1916.)—Five types of reversible cells, namely: cells with reversible metallic electrodes; amalgam cells; gas cells; oxidation and reduction cells; chemical affinity cells, can be treated from the same point of view, provided one starts with the van't Hoff formula, $E = RT/nF \log K\Sigma p_1/\Sigma p_2$, where Σp_1 refers to the substances which are consumed during the reaction and Σp_2 to the substances which are formed, instead of with the simpler equation of Nernst. T. M. L.

743. *Study of the Lead Electrode.* **F. H. Getman.** (Am. Chem. Soc., J. 38. pp. 792–801, April, 1916.)—The author has studied the constancy and reproducibility of the lead electrode in a similar manner to that used in the investigation of the copper electrode [see Abs. 957 (1915)]. Five different types of electrode were investigated in a cell made up according to the scheme: $Pb - \text{sat. sol. } Pb(NO_3)_2 \mid 0{\cdot}10N\text{-}KCl \,.\, Hg_2Cl_2 - Hg$, the lead being negative and the mercury positive. The lead electrodes used were made as follows: (1) Casting purified lead in sticks; (2) amalgamating cast stick electrodes; (3) depositing lead electrolytically on spirals of Pt-wire; (4) depositing lead electrolytically on cast stick electrodes; (5) immersing stick electrodes in an acidified solution of lead acetate (Heller's solution).

The only electrode which proved to be constant and reproducible to within 0·3 millivolt was that in which lead was deposited electrolytically on Pt from an electrolyte of lead nitrate made according to the instructions given by Mathers and McKinney [Abs. 138 (1916)]. The normal electrode potential of lead was calculated to be 0·138 volt at 25°. Freshly cast sticks of lead, after immersion for varying lengths of time in an acidified solution of lead nitrate, lost their ductility and other properties commonly associated with lead, giving a grey mass which is undoubtedly an allotropic modification of lead. The e.m.f. developed at 0° and 25° in cells containing freshly cast lead and the grey modification as electrodes, and $0{\cdot}2N\text{-}Pb(NO_3)_2$ as electrolyte, did not give any positive indication of a transition temperature. Photomicrographs are given showing the rapidity with which freshly cast lead undergoes transformation when immersed in a solution of acidified lead nitrate. T. S. P.